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INVESTIGATION OF METAL PROCESSING TECHNOLOGY

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This report summarizes the research conducted on metal processing over the 42-month period from October 1985 to April 1989. The research includes work on hot isothermal compression testing, lubrication data on ring compression tests, designing and building of high temperature environment chamber for the forge press, designing and building backup tooling for the extrusion press, programming a data acquisition and management system for the extrusion press and reaching the milestone of the facilities 10,000th extrusion. Ir[illegible]rmation derived from this and previous research was applied to the processing of over 3000 billets, bars and melting of numerous alloys. Extrusion data for billets processed under this contract are shown in this report. (AW)

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FOREWORD

This report was prepared by the Westinghouse Electric Corporation, Advanced Energy Systems, Pittsburgh, PA, under USAF Contract No. F33615-85-C-5035. The project was initiated under Project No. 2418, "Metallic Materials," Task No. 2418-03, "Processing-Microstructure-Property Relationships," Work Unit No. 2418-0318 and Program Element No. 62102F. It was administered under the direction of the Wright Aeronautical Laboratories, Wright-Patterson Air Force Base, OH, with Mr. J. T. Morgan (WRDC/MLLM) as Project Engineer.

The work described in this report was carried out between 1 October 1985 and 28 April 1989. Technical and administrative support was provided by:

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The microstructure and therefore the properties of materials are sensitive to thermal treatment and mechanical deformation. A more thorough understanding of the processing-microstructure-property relationship is necessary in order to achieve additional improvements in properties, service life, and cost of components that may be possible from more efficient utilization of processing (thermomechanical treatment) of aerospace materials. The program covered under this contract is aimed at a better understanding of various aspects of the processing-microstructure-property relationship. The experimental effort described in this investigation is a continuation of work carried out at the Materials Laboratory, Wright-Patterson Air Force Base, OH under Contract No. F33615-85-C-5096.

The program consists of two phases. Phase I covered the following areas: Physical modeling of metal powder consolidation and conditioning for the metalworking processes of extrusion and forging; dynamic physical modeling and the development of processing maps from compression tests; and the use of visioplasticity methods to verify analytical models of the various metal deformation processes. Subscale dies were designed and fabricated to be used to produce shapes to verify the analytical models. The materials investigated included alloys of aluminum, nickel-base superalloys, titanium and titanium aluminides which are of interest to the Air Force.

Phase II of the work is directed at applying the knowledge gained from past research in metalworking to support ongoing research and development programs at the WRDC Materials Laboratory. The tasks performed under this phase included extrusion, swaging, forging, melting, heat treatment and welding of experimental alloys of interest to the Air Force. A total of 1192 billets were extruded/compacted. Pertinent data on the materials processed are shown in this report and in the file, records for the particular process; such as, extrusion, swaging, melting, rolling, heat treatment and forging.

The format of this report is such that each task investigated under Phase I is presented as an individual section and include the following:

A. PROCESSING SCIENCE PROGRAM HOT ISOTHERMAL COMPRESSION TESTING WRIGHT STATE UNIVERSITY REPORT
(Raghavan Srinivasan and Joseph F. Thomas, Jr.)

B. LUBRICATION DATA BASE FOR THE EXTRUSION AND FORGING OF NICKEL-BASED ALLOYS
(P. M. French and J. O. Brown)

C. LUBRICANT OPTIMIZATION USING Ti-6Al-4V RING
(Vinod Jain)

D. HIGH TEMPERATURE ENVIRONMENT CHAMBER FOR THE FORGE PRESS
(Vinod Jain)

E. BACKUP TOOLING FOR EXTRUSION PRESS
(Vinod Jain)

F. DATA ACQUISITION AND MANAGEMENT SYSTMEMS FOR THE 700-TON LOMBARD EXTRUSION PRESS AT WRDC
(Ivan A. Martorell)

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J. RETECH CONSUMABL.. NONCONSUMABLE INERT ATMOSPHERE BUTTON MELTING FURNACE

K. GENERAL: POWDER HANDLING FACILITY FOR THE 700-TON LOMBARD EXTRUSION PRESS AT WRDC; 10,000th EXTRUSION
(Ivan A. Martorell, P. M. French)

II. PHASE I - RESEARCH ON VERIFICATION OF ANALYTICAL MODELS AND ON PROCESS DESIGN PARAMETERS

II.A. PROCESSING SCIENCE PROGRAM - HOT ISOTHERMAL COMPRESSION TESTING

WRIGHT STATE REPORT- Raghavan Srinivasan and Joseph F. Thomas, Jr.
Wright State University

Introduction

Thermomechanical deformation processes, such as extrusion, forging and rolling, account for a large fraction of metallic components that are produced. The processing conditions, namely temperature and deformation rates, imposed on the raw or partially finished stock during deformation processing determine, to a large extent, the microstructure, and therefore the properties, of the product. Forging, extrusion, and rolling processes are generally developed with the aim of making products which meet certain service requirements. The product design is usually unalterable, and, hence, it is the job of the process design engineer to determine the optimum temperature, strain rate, number of stages of deformation (forging steps or rolling passes) and other processing conditions that would deliver products with the desired properties.

Traditionally, process design has been a "build-and-test" experience-based procedure. The knowledge, collected over many years of making products with certain materials and certain processes, is used to determine an initial guess. This is then refined after one or more trials to get the required service properties in the product.

Recent developments in computer hardware and software make it possible for an engineer to try out many options by simulating the process he is designing. This eliminates the shopfloor trial-and-error and reduces the amount of critical materials that are used up during process development. The success or failure of the computer-aided design procedure depends on how well material properties under the deformation processing conditions are known. The approach used in this research effort, to determine material flow properties, is to conduct a series of isothermal constant true strain rate compression tests over a large range of temperature and strain rates. The results of these tests and the microstructure of the deformed specimens contain a lot of information useful to the process designer.

Test Facility

The High Temperature Mechanical Test Facility at Wright State University consists of an MTS servohydraulic test frame with a Brew controlled atmosphere radiant heat furnace. The displacement of the actuator can be controlled by a built-in function generator or a signal sent from an IBM P/C. The load and displacement feedback signals from the MTS controller are gathered on a Nicolet digital storage oscilloscope. The oscilloscope is capable of collecting data over a wide range of frequencies, making it possible to monitor tests at strain rates which are several orders of magnitude apart. Data stored by the oscilloscope is transferred to the P/C for analysis. A schematic of the test facility is shown in Figure II.A-1. The various components of the facility were obtained through combined funding from the WRDC Materials Laboratory and the DoD University Research Instrumentation Program through AFOSR. The system has the following unique combination of capabilities:

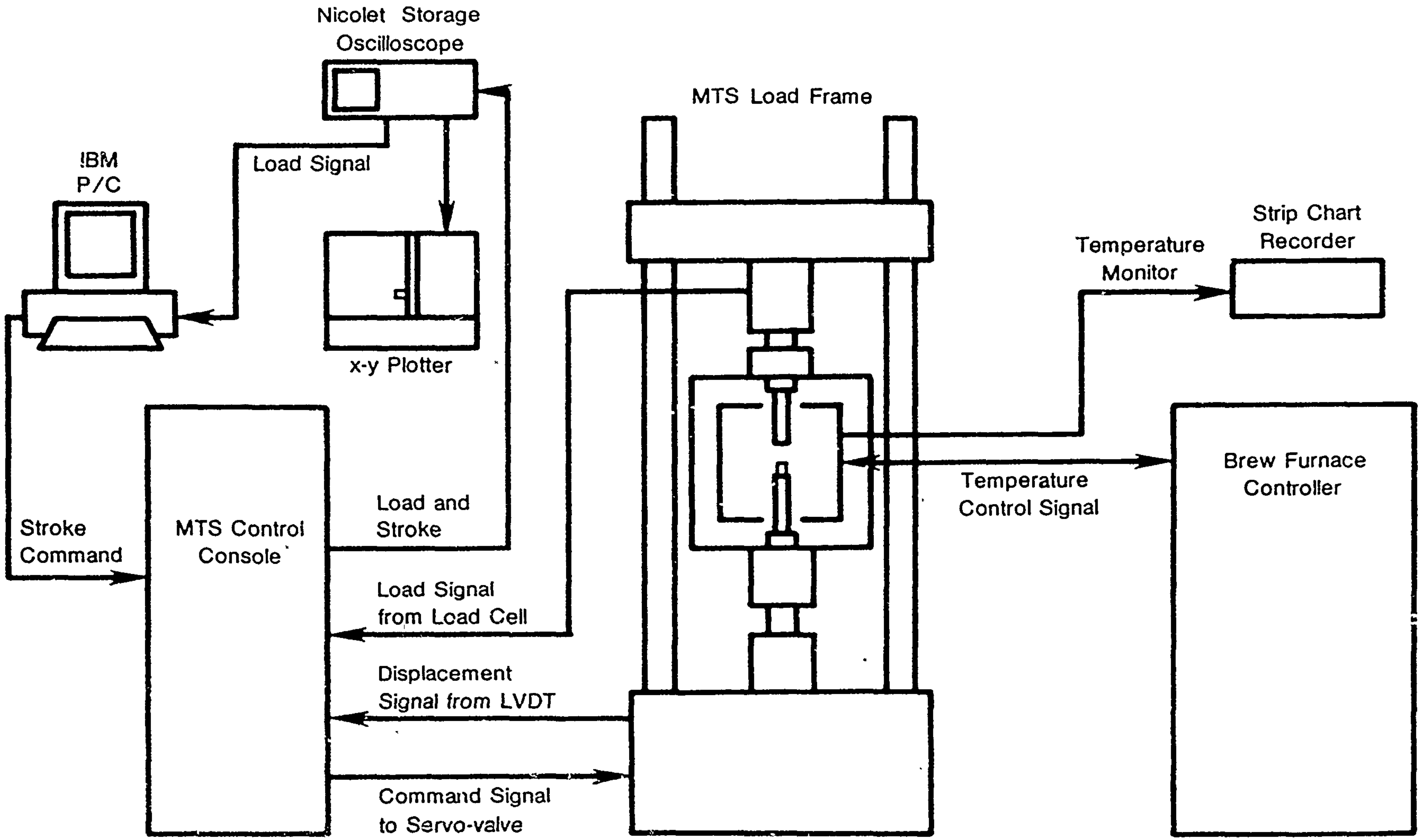


Figure II.A-1. Schematic of High Temperature Mechanical Test Facility at Wright State University.

* Load capacity of 200 kip static and 100 kip at a stroke rate of 10 in./s.

* Two load cells with 200 kip and 20 kip maximum capacity.

* Maximum stroke rate of 12 in./s. Displacement can be controlled by an MTS function generator or a P/C.

* Maximum temperature of 1650°C.

* Vacuum to 10^{-6} torr or inert atmosphere operation.

Tooling

The furnace used in the compression testing system has a maximum operating temperature of 1650°C in vacuum. The tooling for the system was designed with these conditions in mind. Basically, two materials were used: TZM molybdenum alloy for temperatures <1250°C and high strength POCO graphite for higher temperatures. Both these materials have a limited tolerance to oxidizing atmospheres, but, in inert or reducing atmospheres, retain high strength at elevated temperatures.

Test Procedure

Specimens used in this test program were machined to a length-to-diameter ratio of 1.5. The exact dimensions of the specimens varied among the materials. For each test, the specimen was coated with a graphite base lubricant, Deltaforge 31, and mounted between similarly coated platens. The system was heated in vacuum to the test temperature and allowed to soak until the temperature indicated by the monitoring thermocouple was stable for at least 10 min. A signal from the P/C, which took into account the length of the specimen at the test temperature, displaced the actuator as an exponential function of time to give constant true strain rate. After deforming the specimen to the final strain, the heating elements were shut off and the furnace chamber was filled with helium gas. The chamber was opened and the specimen removed after the system temperature was below 50°C. For tests at strain rates below 1.0/s, a simple RC filtering circuit was used to minimize furnace noise in the load signal. At strain rates above 1.0/s, the furnace was shut off just prior to the test to eliminate furnace noise.

Load and stroke signals from the test were collected by the oscilloscope and then transferred to the P/C for analysis. The analysis program took into account the elastic deformation of the specimen and load train, and calculated the true stress - true plastic strain (flow) curves. Whenever a sufficient number of tests for a material were possible, the flow curves were then corrected for deformation heating.

The attached figures (Figures II.A-2 through II.A-46) show the uncorrected flow curves for the various tests conducted. The accompanying tables (Tables II.A-1 through II.A-26) show the test matrix for each material and the uncorrected and corrected stresses at strain values between 0.05 and 0.5 at increments of 0.05, and at the different temperatures and strain rates.

A total of 214 tests were conducted, not all of which were successful. The results and preliminary observations regarding the tests for each material are presented in the sections.

Results

The test program consisted of testing several materials under different conditions of strain rate and temperature. Each material is discussed separately, below.

Rene-80 RSPD

Thirty tests were conducted on this material in the test matrix shown. Many of the specimens showed large surface cracks. Tests at many matrix locations were not conducted because of severe cracking of specimens tested at higher temperature and/or lower strain rate. (Tables II.A-1, II.A-2, and II.A-3 and Figures II.A-2 through II.A-7.)

Rene-95 RSPD

Twenty tests were conducted. The tests were mainly exploratory to determine if there were conditions under which no cracking of the specimens occurred. Only six specimens did not show surface cracks. Rapidly Solidified by Plasma Deposition (RSPD) seems to be a poor method of consolidating Rene powders. (Table II.A-4 and Figures II.A-8 through II.A-11.)

Rene-95 CAP

Forty-one tests were conducted, including five load relaxation tests. The matrix tests yielded specimens without surface cracking over a temperature range of 1040°C to 1160°C and a strain rate range of 0.001/s to 10/s. Data from these tests were corrected for deformation heating and the resultant flow stresses are presented in a table. The results of the load relaxation tests are presented as a table of stress as a function of strain rate and temperature. (Tables II.A-5, II.A-6, II.A-7, II.A-8, II.A-9, and II.A-10 and Figures II.A-12 through II.A-17.)

Isoforged TiAl

This material had previously been forged in a channel die. Specimens had been machined out by EDM, but the orientation with respect to the forging direction was unknown. Twenty-two tests were conducted, two of which were unsuccessful. All specimens deformed from a round cross section to a shape approximately elliptical. This anisotropy in deformation decreased at 1300°C, and was almost absent at 1350°C. (Tables II.A-11, II.A-12, II.A-13, II.A-14, and II.A-15 and Figures II.A-18 through II.A-22.)

Tungsten

Two compression tests were conducted at 0.01/s and temperatures of 697°C and 798°C on request from Westinghouse Electric Corporation. (Table II.A-16 and Figure II.A-23.)

Ti-15V-3Al-3Cr-3Sn

A series of 34 tests were conducted on this alloy on a research effort for WRDC/MLLS. An initial matrix of 18 tests were conducted on large columnar grain as-cast specimens, 1.33-in.-diameter and 2-in.-high. A second generation of specimens 0.75-in.-high and 0.5-in.-diameter was machined from the deformed specimens. These specimens were annealed to a fully recrystallized structure and tested again. A third generation of specimens was machined from deformed second generation specimens. These were then annealed and tested again. This test program is continuing with other sources of support. (Tables II.A-17, II.A-18, II.A-19, II.A-20, II.A-21, and II.A-22 and Figures II.A-24 through II.A-34.)

Ti-6Al-7Sn-4Zr-0.2Si

Thirty tests were conducted. This material shows yield stress peaks at high temperatures and at low and high strain rates, but not at intermediate strain rates. This may be worth investigating further. There is shear banding and fracture at low temperatures and high strain rates. (Tables II.A-23, II.A-24, and II.A-25 and Figures II.A-35 through II.A-40.)

Rene-88 (W2)

This material is of interest to the Air Force and was selected after consultation with engineers at General Electric Co., Evendale, OH. Sixty specimens were machined by EDM from a pancake of the material received from Cameron Iron. The processing history and exact composition have not been revealed to us at this point. A 48-test matrix was suggested by General Electric Co. Thirty-four tests have been conducted, including a few unsuccessful ones. Partial results are presented. Testing on this project is continuing with other sources of support. (Table II.A-26 and Figures II.A-41 through II.A-46.)

TABLE II.A-1: Rene-80 RSPD Test Matrix

Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}
980					
1010	R80PD6	R80PD7A			
1040	R80PD11	R80PD12	R80PD13		
1070	R80PD16	R80PD17	R80PD18		
1100	R80PD21	R80PD22A	R80PD23A	R80PD24	R80PD25
1130	R80PD26	R80PD27	R80PD28A	R80PD29	R80PD30
1160	R80PD31	R80PD32	R80PD33	R80PD34	R80PD35

Note: Many of the specimens showed gross surface cracks. Matrix locations which are blank are tests which were not conducted because of severe cracking of specimens under test conditions of higher temperature and/or lower strain rate.

TABLE II.A-2: Rene-80 RSPD Flow Stress Data
Flow Stress in MPa

(Not Corrected for Deformation Heating)

Strain	Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}
0.05	1010	378.037	408.430	0.000	0.000	0.000
	1040	285.617	324.070	427.384	0.000	0.000
	1070	226.794	247.648	357.123	0.000	0.000
	1100	164.508	193.199	288.651	358.904	465.044
	1130	123.848	131.780	194.133	292.779	351.082
	1160	60.878	83.061	106.034	177.103	251.259
0.10	1010	383.263	421.585	0.000	0.000	0.000
	1040	294.712	335.939	417.742	0.000	0.000
	1070	231.596	256.430	351.552	0.000	0.000
	1100	170.568	201.248	286.690	358.420	456.183
	1130	133.875	139.531	194.589	293.173	354.827
	1160	71.740	87.723	108.511	179.600	245.058
0.15	1010	372.353	425.794	0.000	0.000	0.000
	1040	288.706	339.452	401.678	0.000	0.000
	1070	227.040	260.438	340.136	0.000	0.000
	1100	167.977	204.962	279.256	350.471	444.885
	1130	134.279	145.826	191.779	288.531	347.241
	1160	76.358	91.931	109.281	178.247	239.164
0.20	1010	351.794	419.779	0.000	0.000	0.000
	1040	273.069	334.870	380.762	0.000	0.000
	1070	215.253	259.655	324.239	0.000	0.000
	1100	160.963	205.072	268.481	340.466	432.026
	1130	130.593	150.604	187.548	281.643	335.594
	1160	77.006	95.408	108.712	175.299	232.224
0.25	1010	323.945	406.078	0.000	0.000	0.000
	1040	252.437	324.295	356.873	0.000	0.000
	1070	201.407	254.566	305.714	0.000	0.000
	1100	151.506	202.474	255.380	326.360	414.082
	1130	125.027	152.597	182.120	271.810	320.825
	1160	76.264	97.980	107.111	170.687	224.593

TABLE II.A-3: Rene-80 RSPD Flow Stress Data
Flow Stress in MPa

(Not Corrected for Deformation Heating)

Strain	Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}
0.30	1010	296.166	378.037	0.000	0.000	0.000
	1040	229.901	308.811	330.248	0.000	0.000
	1070	185.277	245.666	286.300	0.000	0.000
	1100	141.555	197.009	239.959	309.049	390.825
	1130	118.467	152.461	174.276	259.912	303.375
	1160	73.354	99.459	104.294	164.503	214.080
0.35	1010	267.718	364.723	0.000	0.000	0.000
	1040	208.523	291.121	305.708	0.000	0.000
	1070	170.117	234.066	267.131	0.000	0.000
	1100	131.274	190.212	224.548	289.218	364.307
	1130	104.458	147.476	160.266	232.152	265.463
	1160	67.583	100.308	98.328	150.625	192.755
0.40	1010	242.986	341.546	0.000	0.000	0.000
	1040	190.117	274.037	282.595	0.000	0.000
	1070	155.851	222.261	250.265	0.000	0.000
	1100	121.229	181.986	213.392	268.967	336.664
	1130	104.458	147.476	160.266	232.152	265.463
	1160	67.583	100.308	98.328	150.625	192.755
0.45	1010	222.099	319.903	0.000	0.000	0.000
	1040	173.811	258.128	261.561	0.000	0.000
	1070	143.779	211.010	235.314	0.000	0.000
	1100	111.913	173.507	201.802	250.406	312.140
	1130	98.034	143.549	154.430	218.690	249.016
	1160	62.569	99.393	95.896	144.292	184.156
0.50	1010	205.052	300.437	0.000	0.000	0.000
	1040	161.145	243.661	244.212	0.000	0.000
	1070	133.001	200.367	222.160	0.000	0.000
	1100	105.492	165.784	191.306	233.806	279.662
	1130	90.835	138.951	149.130	206.208	279.662
	1160	60.124	98.358	93.682	138.644	176.417

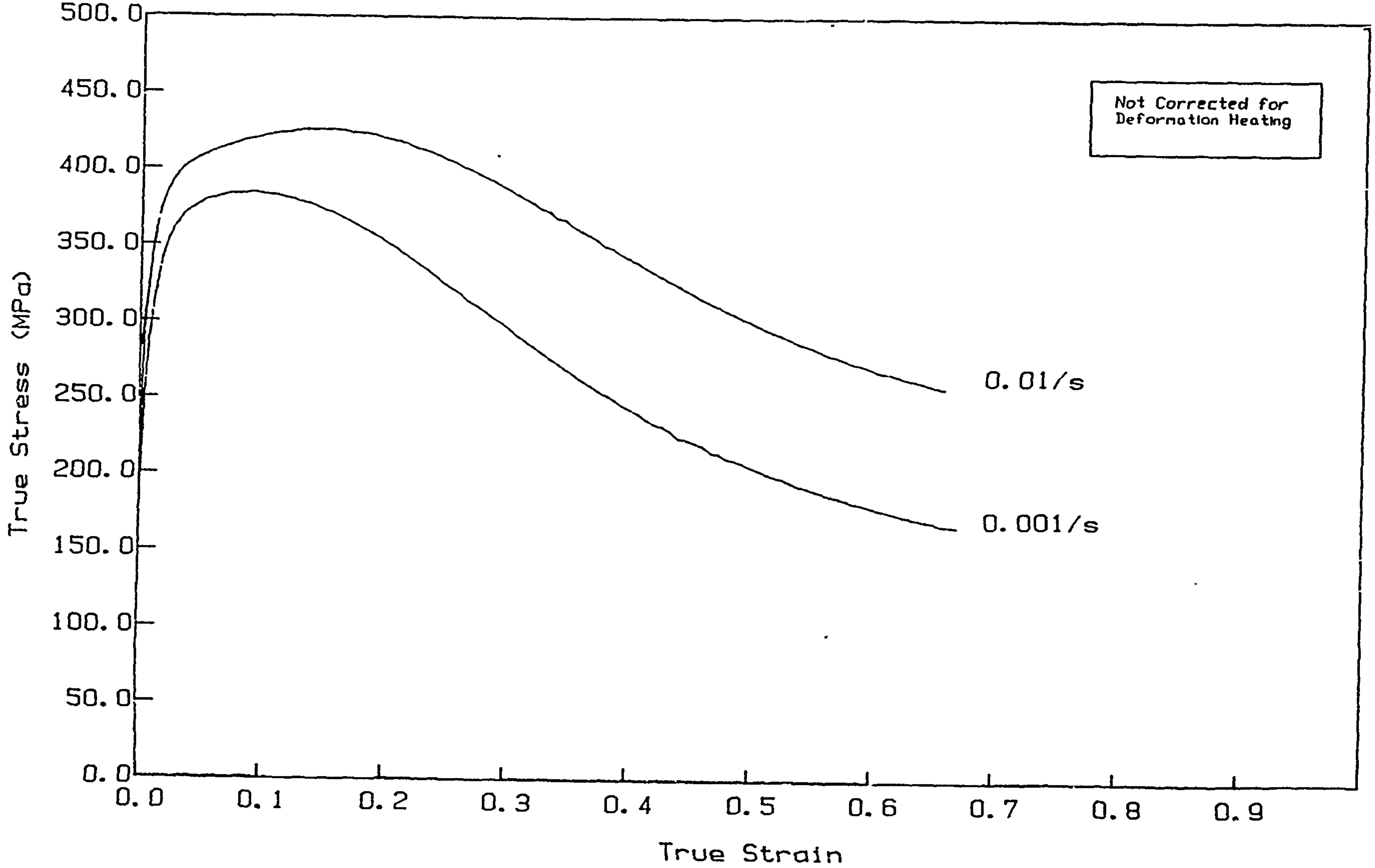


Figure II.A-2. Rene-80 RSPD Tested at 1010°C.

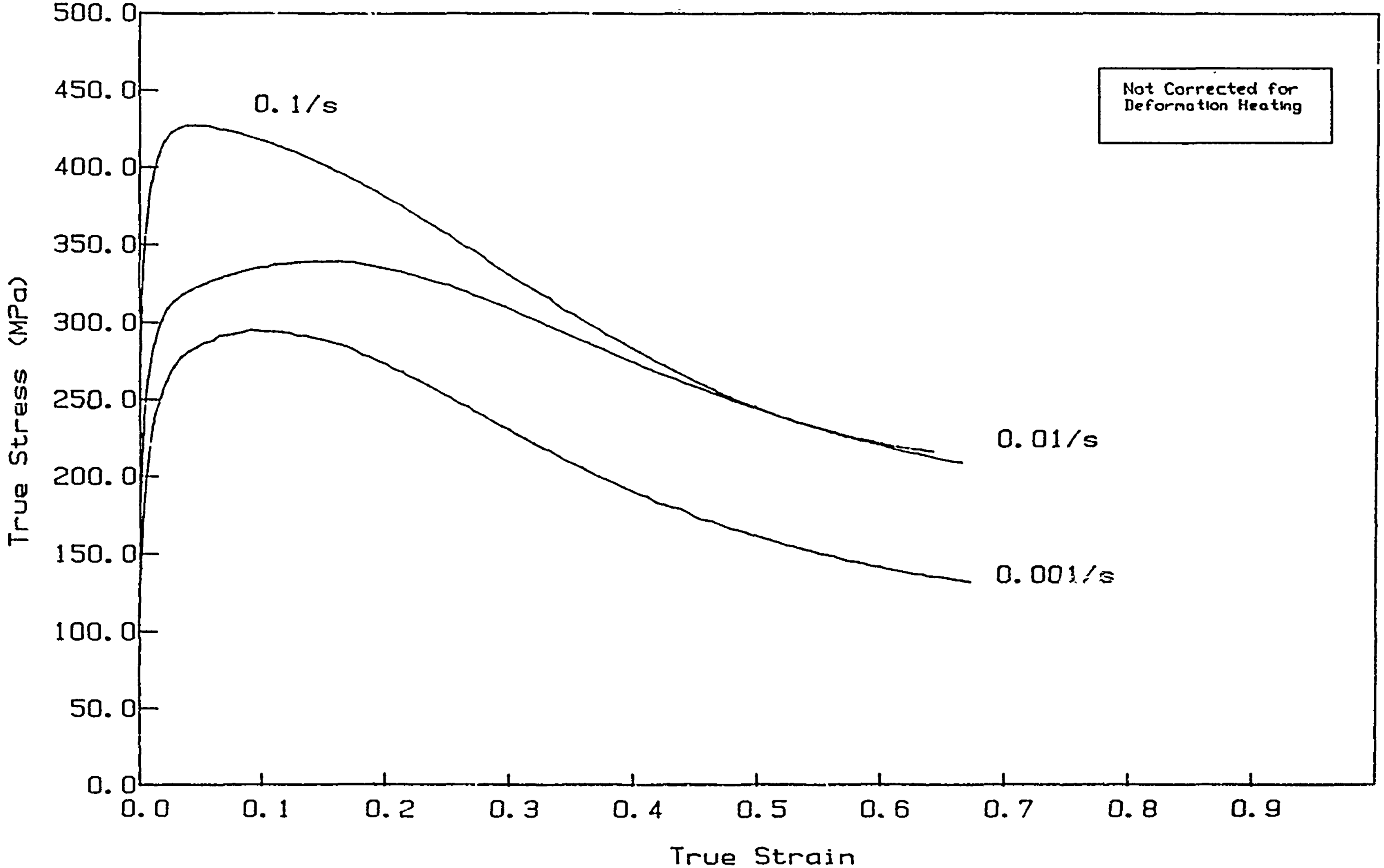


Figure II.A-3. Rene-80 RSPD Tested at 1040°C.

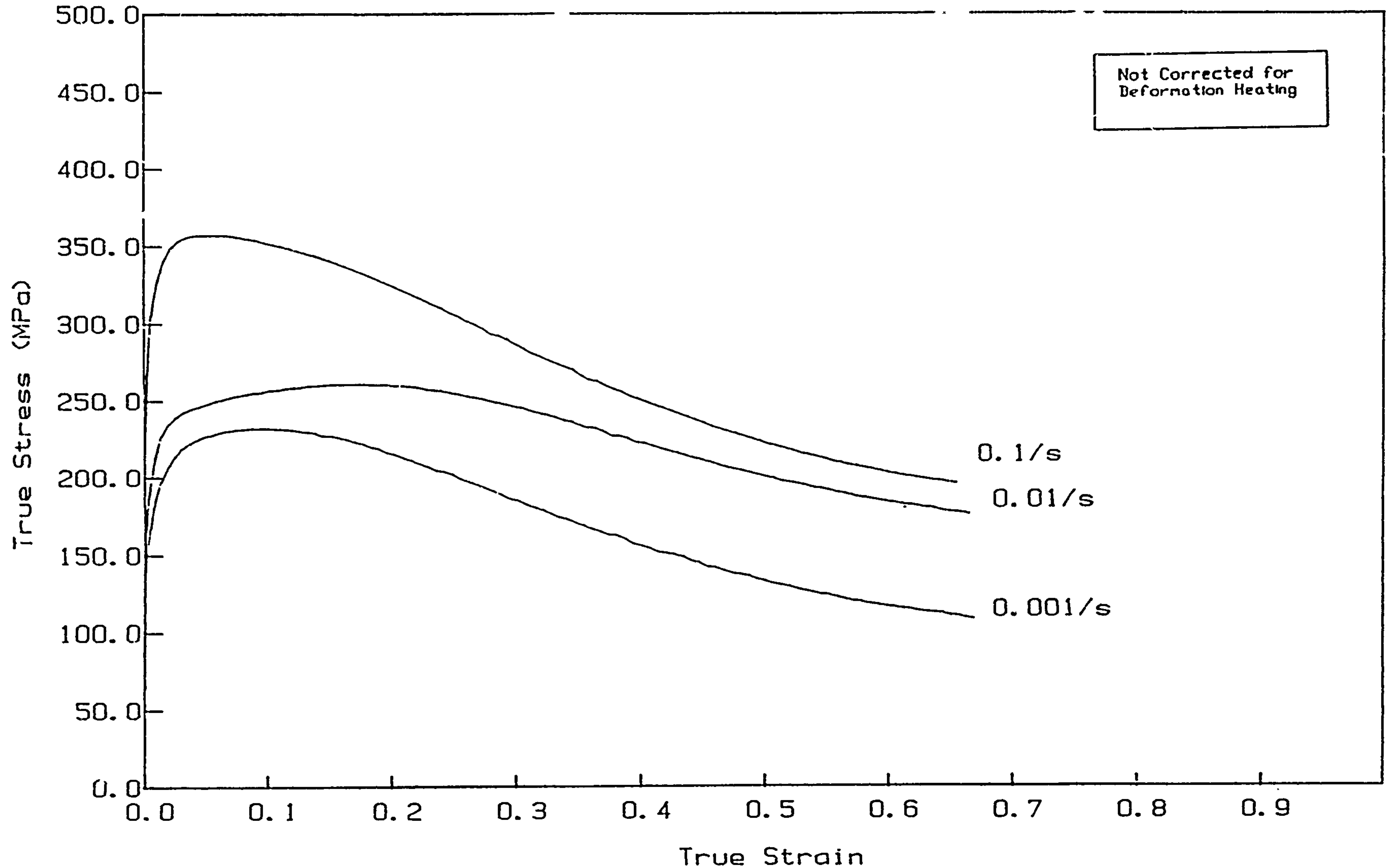


Figure II.A-4. Rene-80 RSPD Tested at 1070°C.

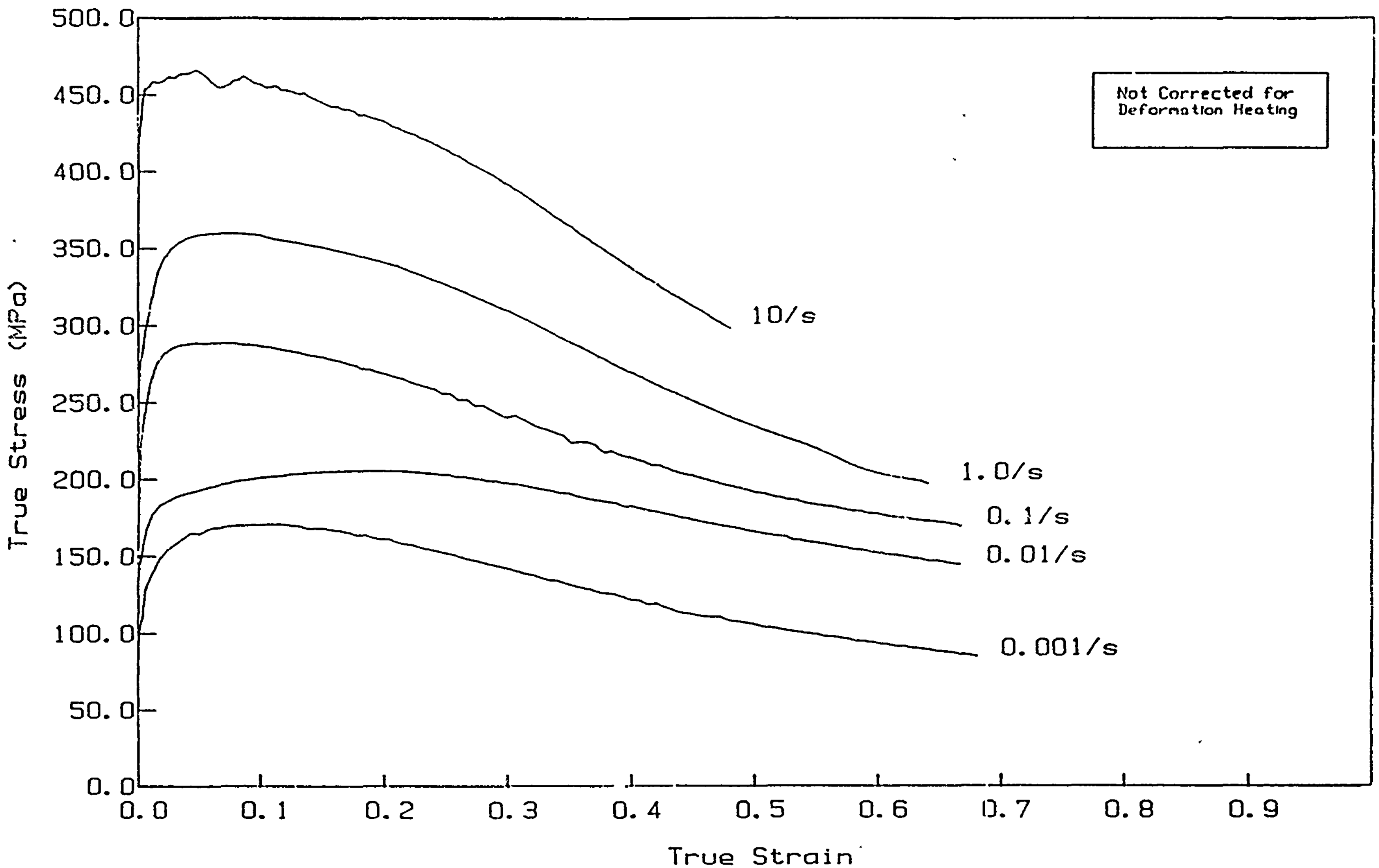


Figure II.A-5. Rene-80 RSPD Tested at 1100°C.

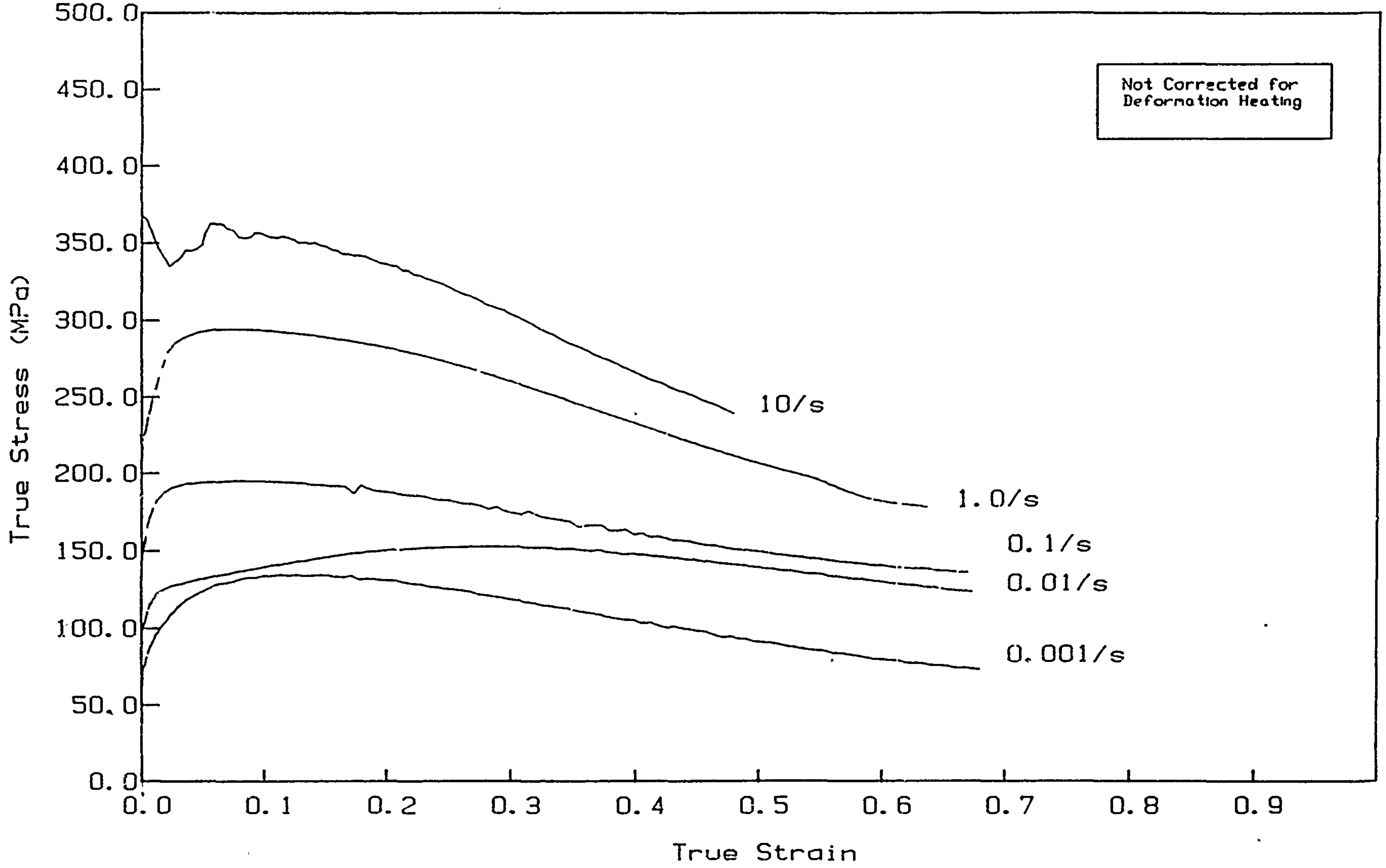


Figure II.A-6. Rene-80 RSPD Tested at 1130°C.

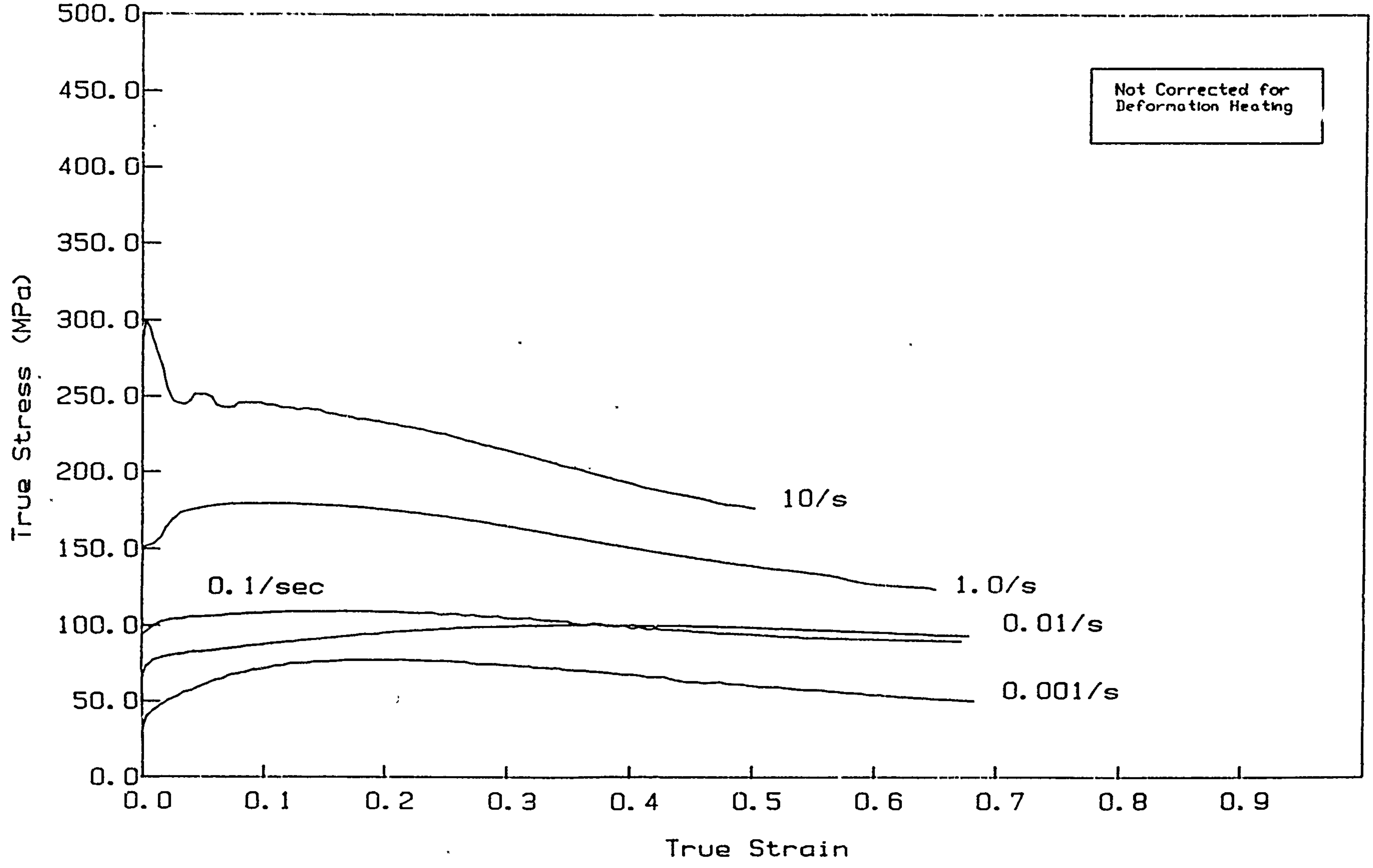


Figure II.A-7. Rene-80 RSPD Tested at 1160°C.

TABLE II.A-4: Rene-95 RSPD Test Matrix

Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}
980					
1010			R95PD8		
1040	R95PD11				
1070	R95PD17	R95PD18			
1100	R95PD21*	R95PD22	R95PD23	R95PD24	
1130	R95PD26	R95PD27	R95PD28*	R95PD29	
1160	R95PD31	R95PD32	R95PD33*	R95PD34*	R95PD35
1190			R95PD38*	R95PD39*	

Note: This table lists the tests conducted. All tests, except those marked by *, cracked during deformation and flow stresses could not be calculated. The few flow curves that could be calculated are shown.

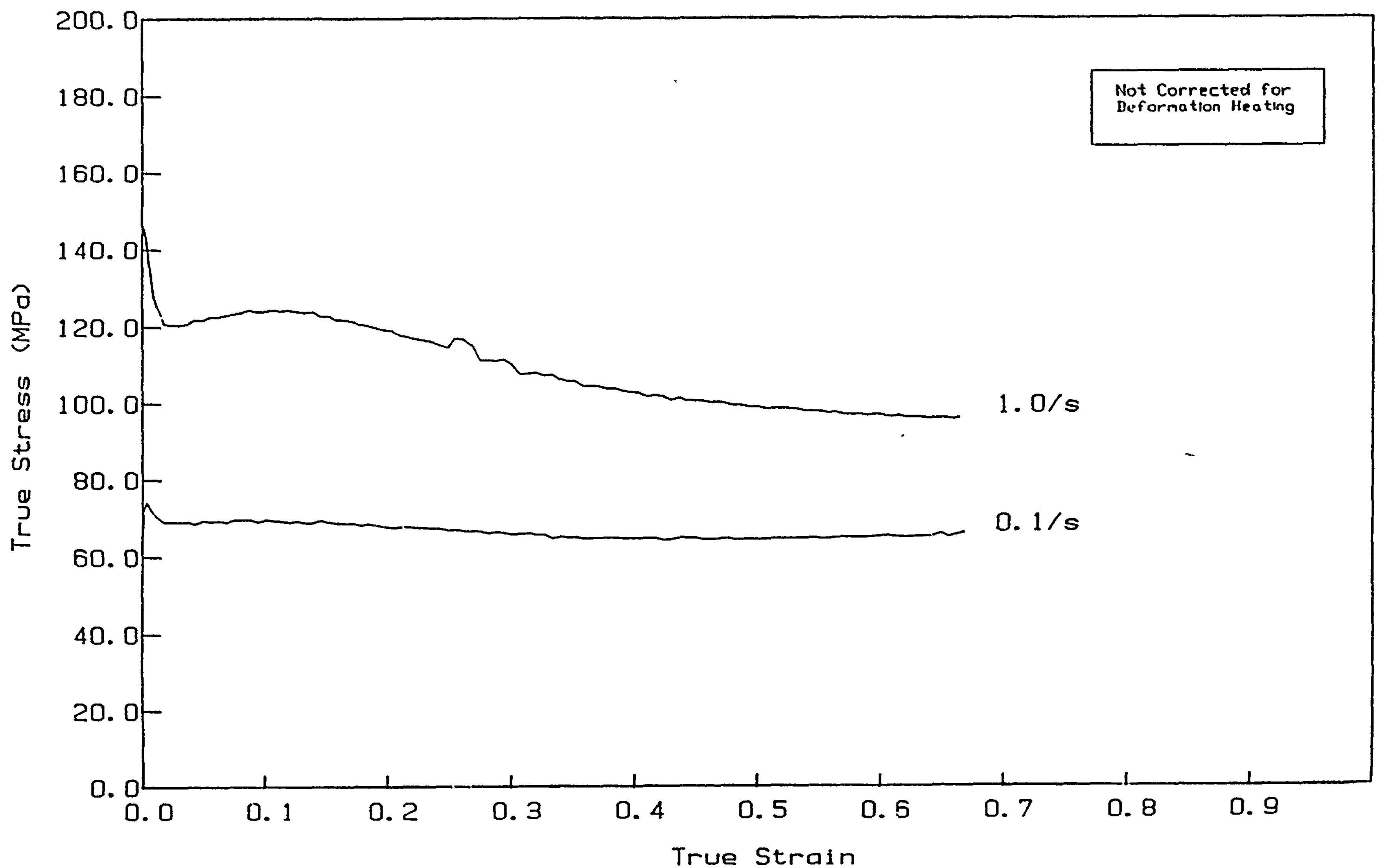


Figure II.A-8. Rene-95 RSPD Tested at 1190°C.

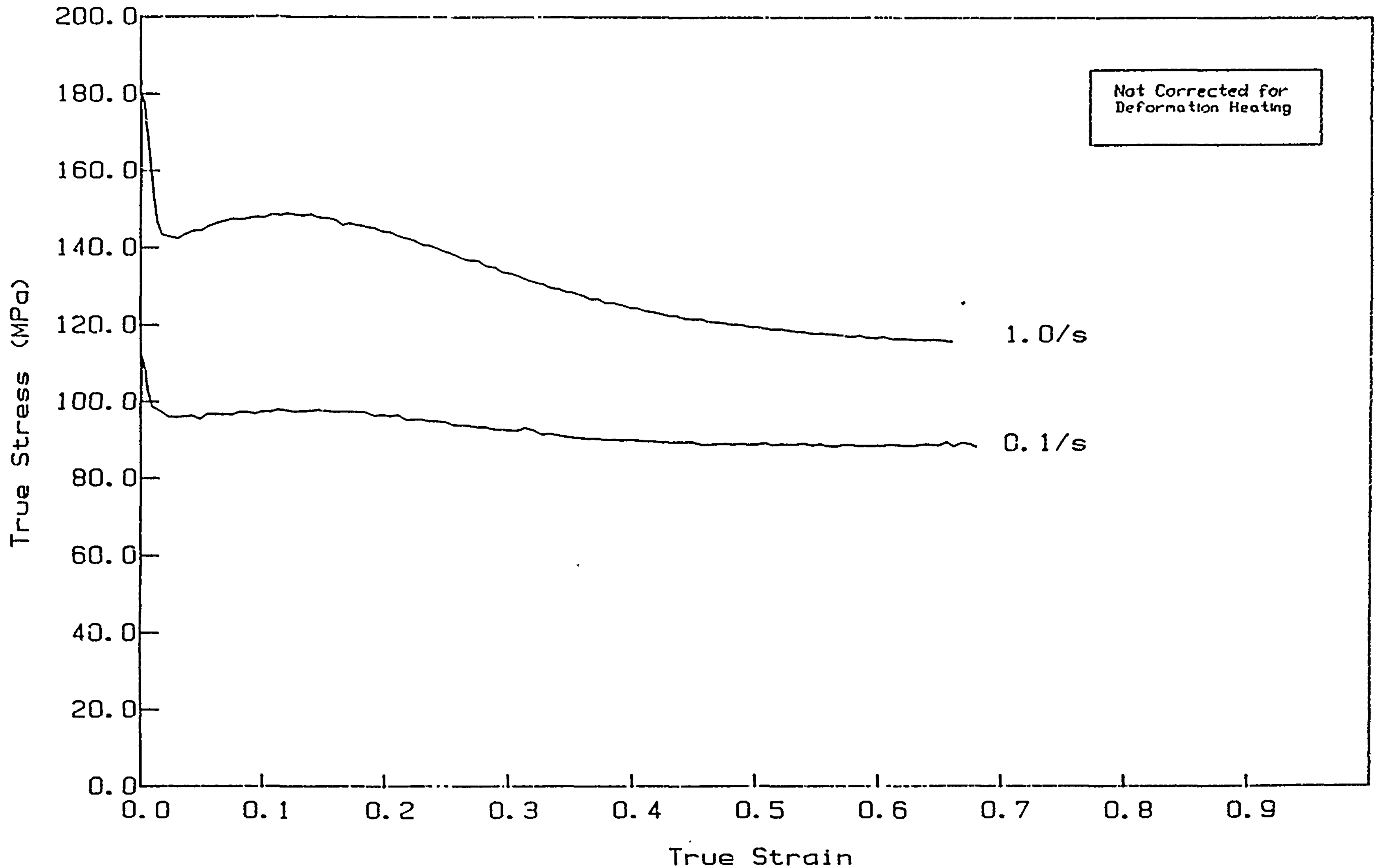


Figure II.A-9. Rene-95 RSPD Tested at 1160°C.

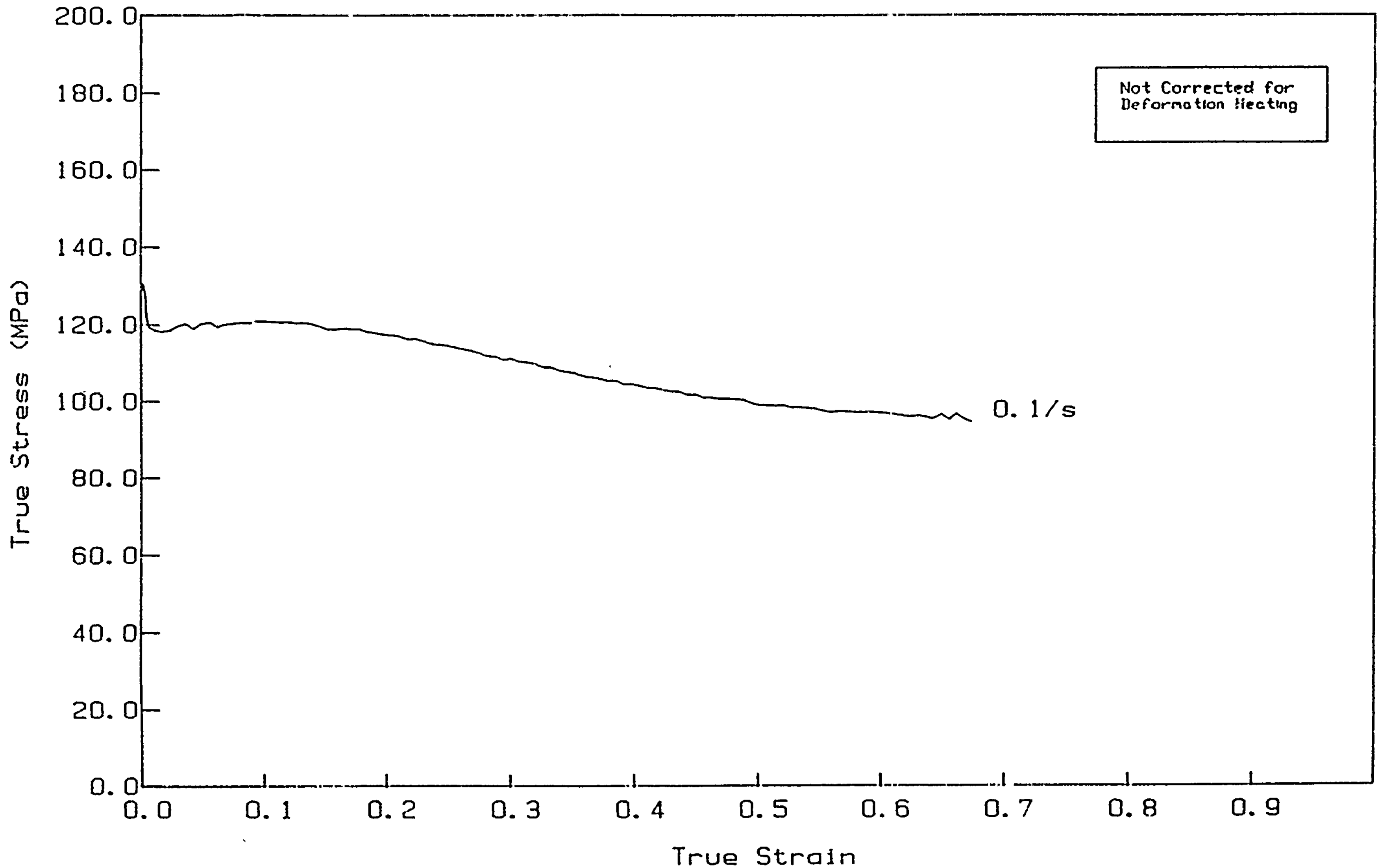


Figure II.A-10. Rene-95 RSPD Tested at 1130°C.

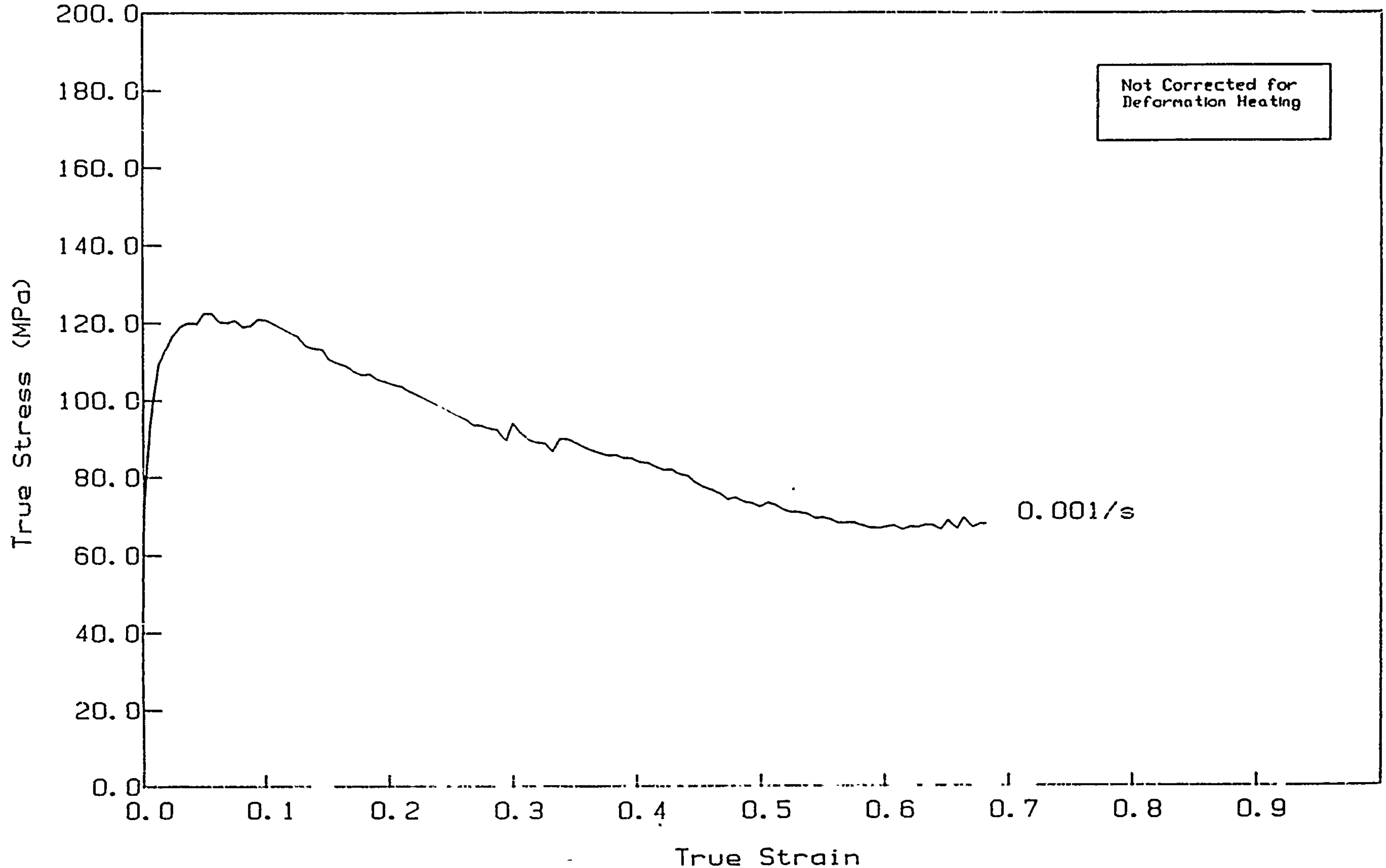


Figure II.A-11. Rene-95 RSPD Tested at 1100°C.

TABLE II.A-5: Rene-95 CAP Test Matrix

Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}
980					
1010	R95CAP6				
1040	R95CAP11	R95CAP12	R95CAP13	R95CP14A	R95CAP15
1070	R95CAP16	R95CAP17	R95CAP18	R95CP19A	R95CAP20
1100	R95CAP21*	R95CAP22	R95CAP23	R95CP24A	R95CP25A
1130	R95CAP26	R95CAP27	R95CAP28	R95CAP29C	R95CAP30
1160	R95CP31A	R95CP32A	R95CAP33	R95CAP34	R95CP35B

Note: This table lists the tests conducted.
R95CAP6 showed surface cracks.
No other tests were done at temperatures 1010°C and below.

TABLE II.A-6: Rene-95 CAP Flow Stress Data
Flow Stress in MPa

(Not Corrected for Deformation Heating)

Strain	Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}
0.05	1040	213.051	253.923	355.147	504.570	629.268
	1070	150.218	192.124	258.542	408.992	519.934
	1100	102.471	160.084	233.233	329.677	448.171
	1130	36.718	96.951	170.871	275.997	352.S07
	1160	35.213	54.859	89.722	153.627	270.931
0.10	1040	218.841	267.241	358.405	511.222	636.665
	1070	157.868	200.117	259.554	416.605	524.088
	1100	111.203	165.274	233.605	337.281	450.073
	1130	40.277	97.041	171.716	282.481	355.628
	1160	39.036	59.442	93.178	155.845	267.022
0.15	1040	213.138	272.888	350.306	504.402	632.577
	1070	155.791	204.199	252.252	409.265	519.850
	1100	114.735	166.936	226.773	332.765	444.287
	1130	44.115	90.462	168.348	279.199	343.747
	1160	37.515	60.213	92.584	153.648	261.671
0.20	1040	204.416	271.261	336.140	492.282	621.054
	1070	152.220	202.320	241.038	397.187	508.211
	1100	111.256	165.656	216.168	320.558	435.984
	1130	44.876	94.927	161.339	268.909	337.955
	1160	38.274	57.673	88.319	148.283	253.052
0.25	1040	192.117	264.424	315.942	470.829	601.997
	1070	146.507	196.492	226.281	379.167	492.578
	1100	111.730	162.382	203.650	305.444	421.207
	1130	43.726	94.004	152.491	255.523	328.311
	1160	38.670	56.718	83.793	141.566	241.847
0.30	1040	179.023	255.167	295.206	445.584	578.354
	1070	138.866	189.025	211.172	356.387	472.953
	1100	108.528	156.944	192.562	285.645	403.065
	1130	44.143	93.071	144.450	239.822	313.695
	1160	37.823	56.482	80.527	134.697	230.474

TABLE II.A-7: Rene-95 CAP Flow Stress Data
Flow Stress in MPa

(Not Corrected for Deformation Heating)

Strain	Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}
0.35	1040	166.488	243.574	277.177	415.191	549.888
	1070	130.706	180.158	196.776	331.624	449.696
	1100	103.662	151.067	180.344	264.621	381.725
	1130	44.046	90.690	136.262	223.338	296.716
	1160	37.228	56.563	78.974	128.584	218.732
0.40	1040	153.452	231.974	257.708	382.736	518.762
	1070	121.737	171.597	186.747	306.863	423.050
	1100	97.845	144.692	170.078	244.538	359.335
	1130	43.965	88.830	129.700	207.618	281.025
	1160	37.482	56.110	77.683	123.333	207.138
0.45	1040	142.012	220.111	240.936	350.342	483.958
	1070	114.629	163.221	177.420	283.595	395.853
	1100	92.110	138.407	161.739	226.651	335.063
	1130	43.265	86.254	124.119	194.136	264.491
	1160	37.707	56.354	76.825	118.718	196.846
0.50	1040	132.979	208.906	226.491	321.740	
	1070	107.783	155.478	169.819	262.449	368.764
	1100	87.168	132.817	155.050	210.971	312.077
	1130	42.982	84.038	119.804	182.266	248.534
	1160	37.455	56.500	76.317	115.104	183.296

TABLE II.A-8: Rene-95 CAP Flow Stress Data
Flow Stress in MPa

(Not Corrected for Deformation Heating)

Strain	Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}
0.05	1040	213.051	253.923	355.147	504.570	629.268
	1070	150.218	193.082	258.542	408.992	519.934
	1100	102.471	160.084	233.233	329.677	448.171
	1130	36.718	97.390	170.871	275.997	352.807
	1160	35.213	55.018	89.722	153.627	270.931
0.10	1040	218.841	267.241	358.405	511.222	636.665
	1070	157.868	200.117	259.554	416.605	524.088
	1100	111.203	165.274	233.605	337.281	450.073
	1130	40.277	97.041	171.716	282.481	355.628
	1160	39.036	59.442	93.178	155.845	267.022
0.15	1040	213.138	272.888	350.306	504.402	632.577
	1070	155.791	204.199	252.252	409.265	519.850
	1100	114.735	166.936	226.773	332.765	444.287
	1130	44.115	90.462	168.348	279.199	343.747
	1160	37.515	60.213	92.584	153.648	261.671
0.20	1040	204.416	271.261	336.140	492.282	621.054
	1070	152.220	202.320	241.038	397.187	508.211
	1100	111.256	165.656	216.168	320.558	435.984
	1130	44.876	94.927	161.339	268.909	337.955
	1160	38.274	57.673	88.319	148.283	253.052
0.25	1040	192.117	264.424	315.942	470.829	601.997
	1070	146.507	196.492	226.281	379.167	492.578
	1100	111.730	162.382	203.650	305.444	421.207
	1130	43.726	94.004	152.491	255.523	328.311
	1160	38.670	56.718	83.793	141.566	241.847
0.30	1040	179.023	255.167	295.206	445.584	578.354
	1070	138.866	189.025	211.172	356.387	472.953
	1100	108.528	156.944	192.562	285.645	403.065
	1130	44.143	93.071	144.450	239.822	313.695
	1160	37.823	56.482	80.527	134.697	230.474

TABLE II.A-9: Rene-95 CAP Flow Stress Data
Flow Stress in MPa

(Not Corrected for Deformation Heating)

Strain	Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}
0.35	1040	166.488	257.595	330.742	491.888	670.031
	1070	130.706	187.515	222.310	378.155	525.438
	1100	103.662	153.948	184.965	293.447	422.879
	1130	44.046	93.699	145.140	237.802	336.839
	1160	37.228	57.587	84.583	145.727	244.946
0.40	1040	153.452	247.211	311.135	462.719	653.388
	1070	121.737	179.575	212.690	355.421	507.354
	1100	97.845	147.725	175.327	275.095	403.659
	1130	43.965	92.056	138.953	222.273	323.780
	1160	37.482	57.243	83.616	141.207	235.681
0.45	1040	142.012	236.170	294.068	428.988	625.595
	1070	114.629	171.636	203.636	331.735	484.547
	1100	92.110	141.533	167.193	257.899	382.705
	1130	43.265	89.668	133.754	208.500	308.225
	1160	37.707	57.542	83.010	137.096	226.431
0.50	1040	132.979	225.515	278.257	398.591	627.112
	1070	107.783	164.203	195.870	309.827	471.320
	1100	87.168	135.967	160.658	242.136	361.386
	1130	42.982	87.609	129.770	196.175	292.504
	1160	37.455	57.738	82.654	133.654	214.964

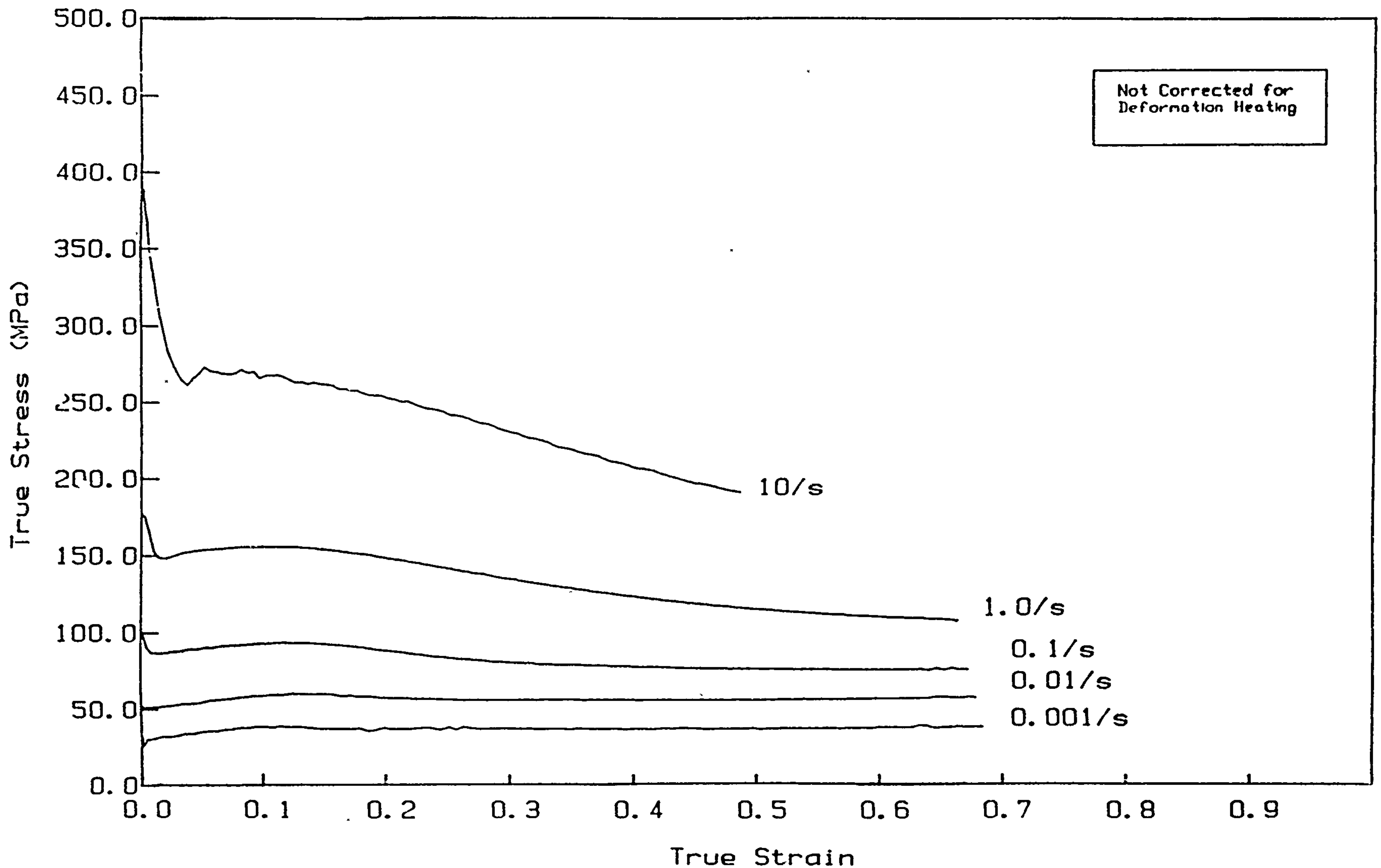


Figure II.A-12. Rene-95 CAP Tested at 1160°C.

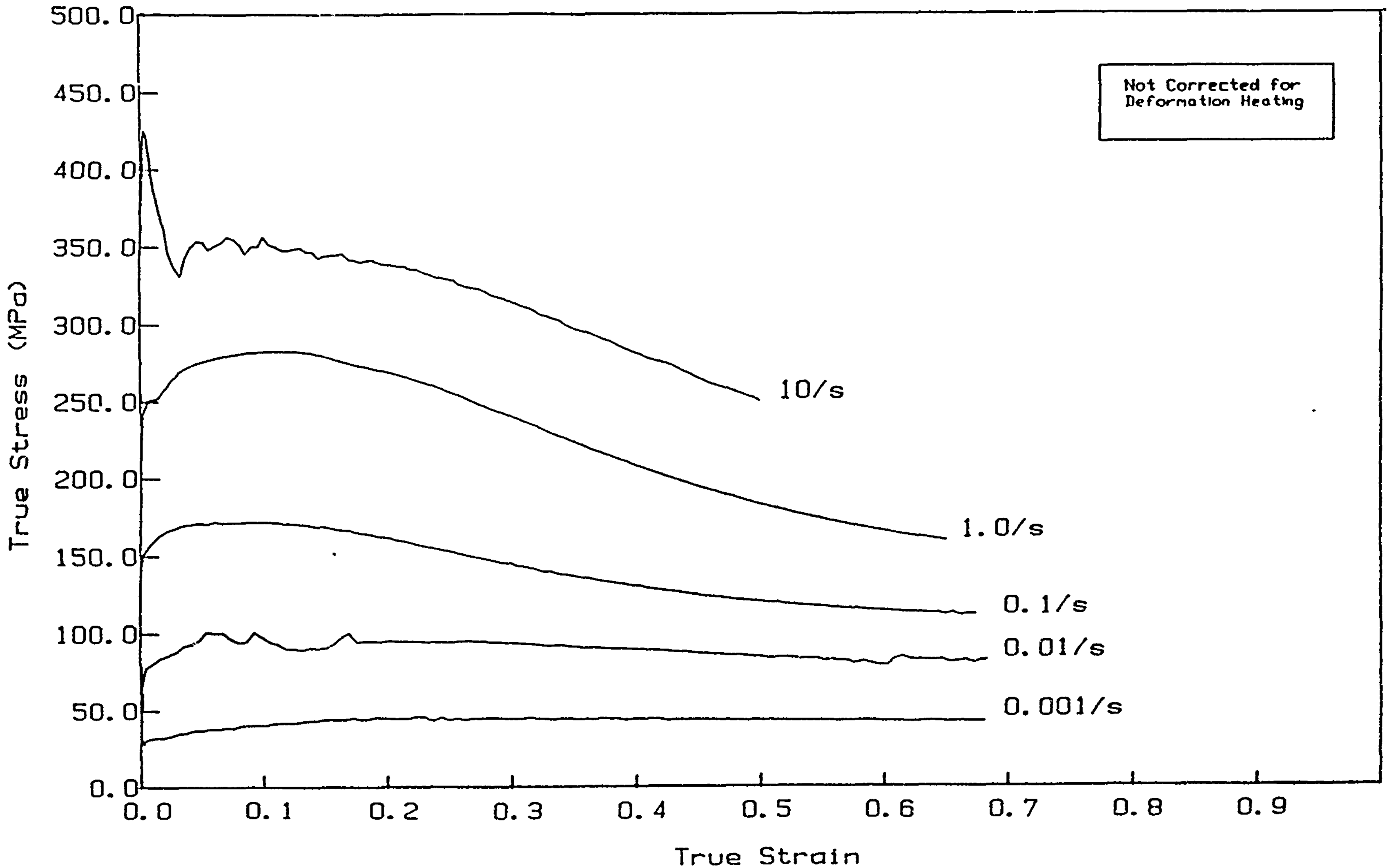


Figure II.A-13. Rene-95 CAP Tested at 1130°C.

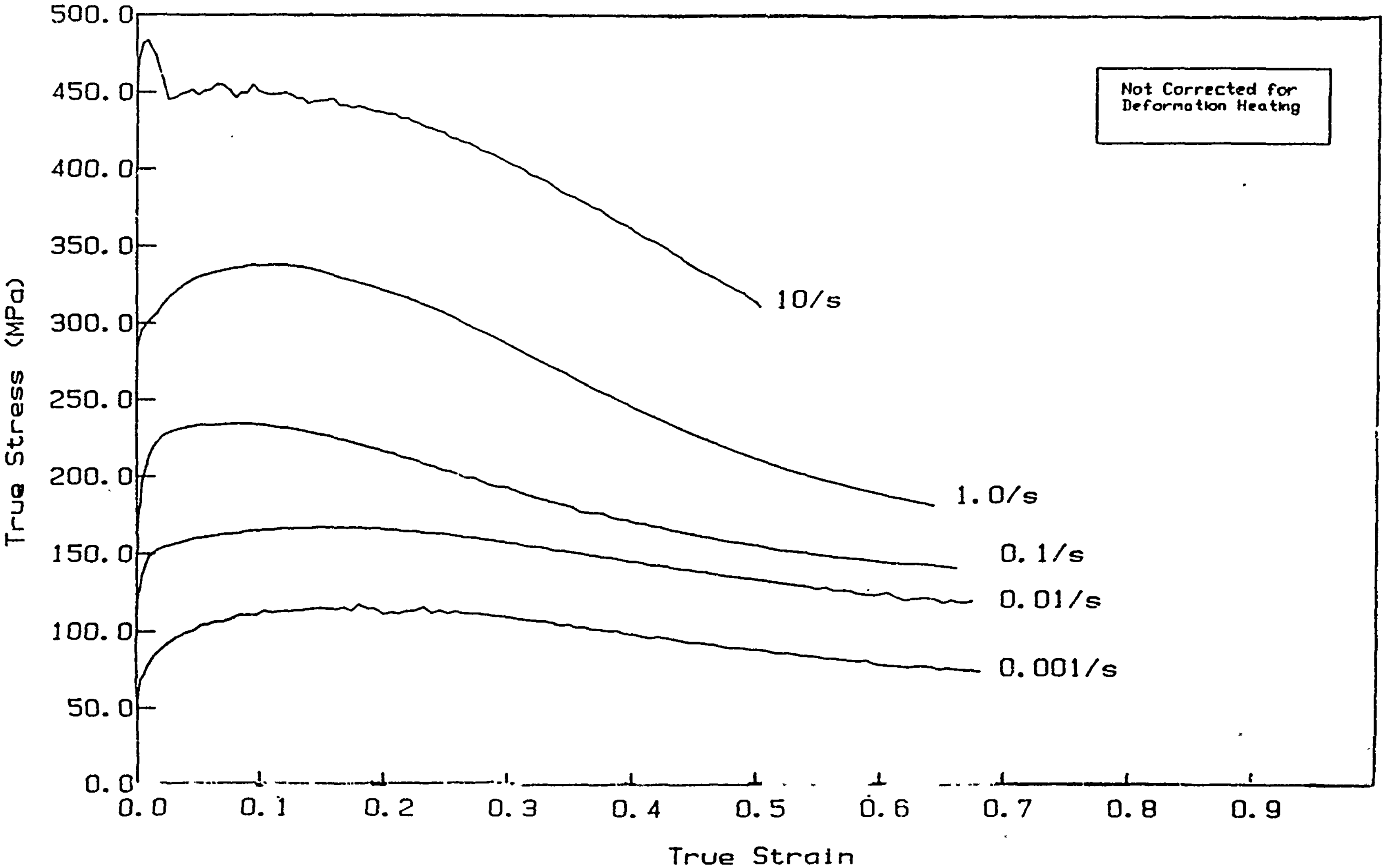


Figure II.A-14. Rene-95 CAP Tested at 1100°C.

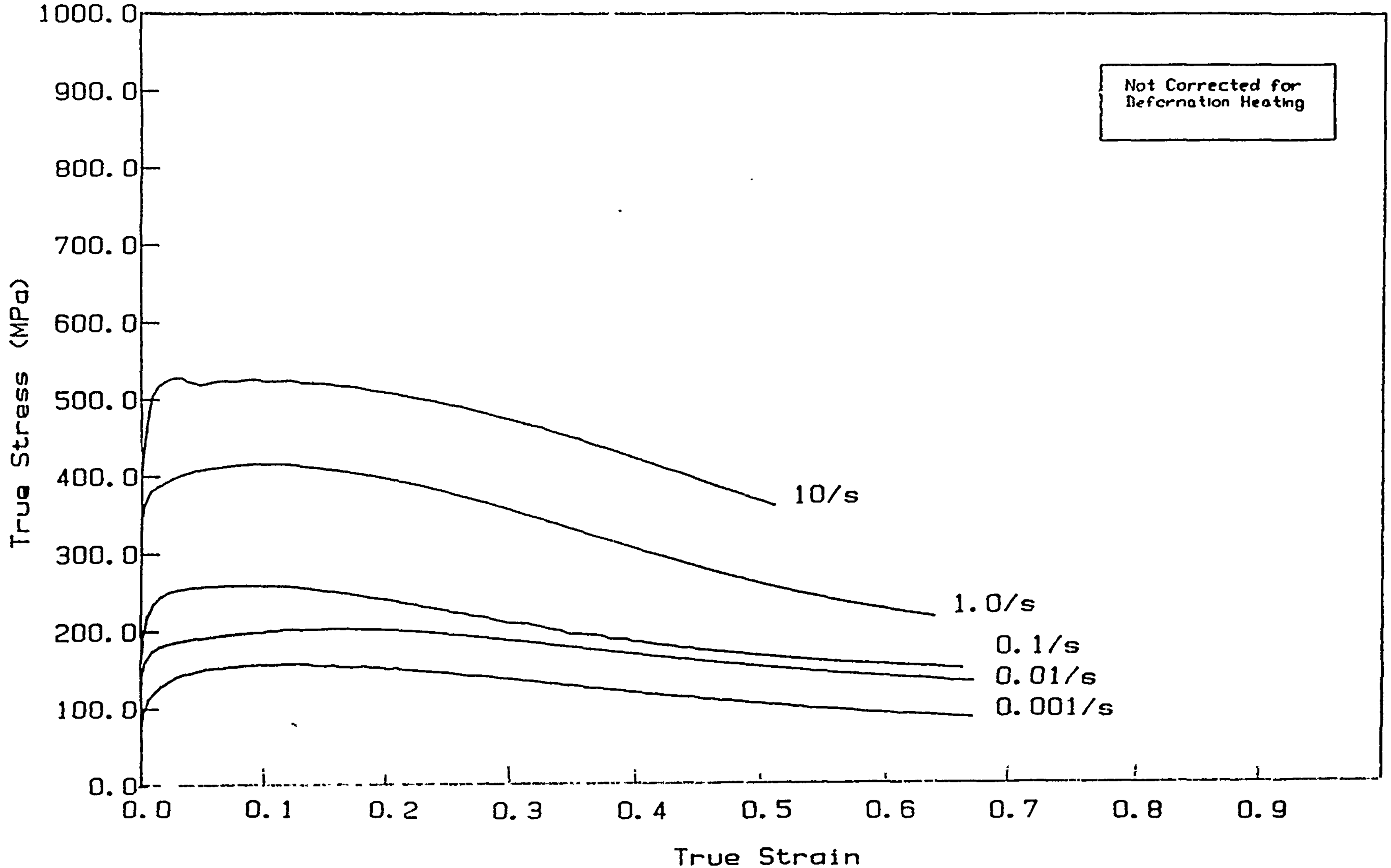


Figure II.A-15. Rene-95 CAP Tested at 1070°C.

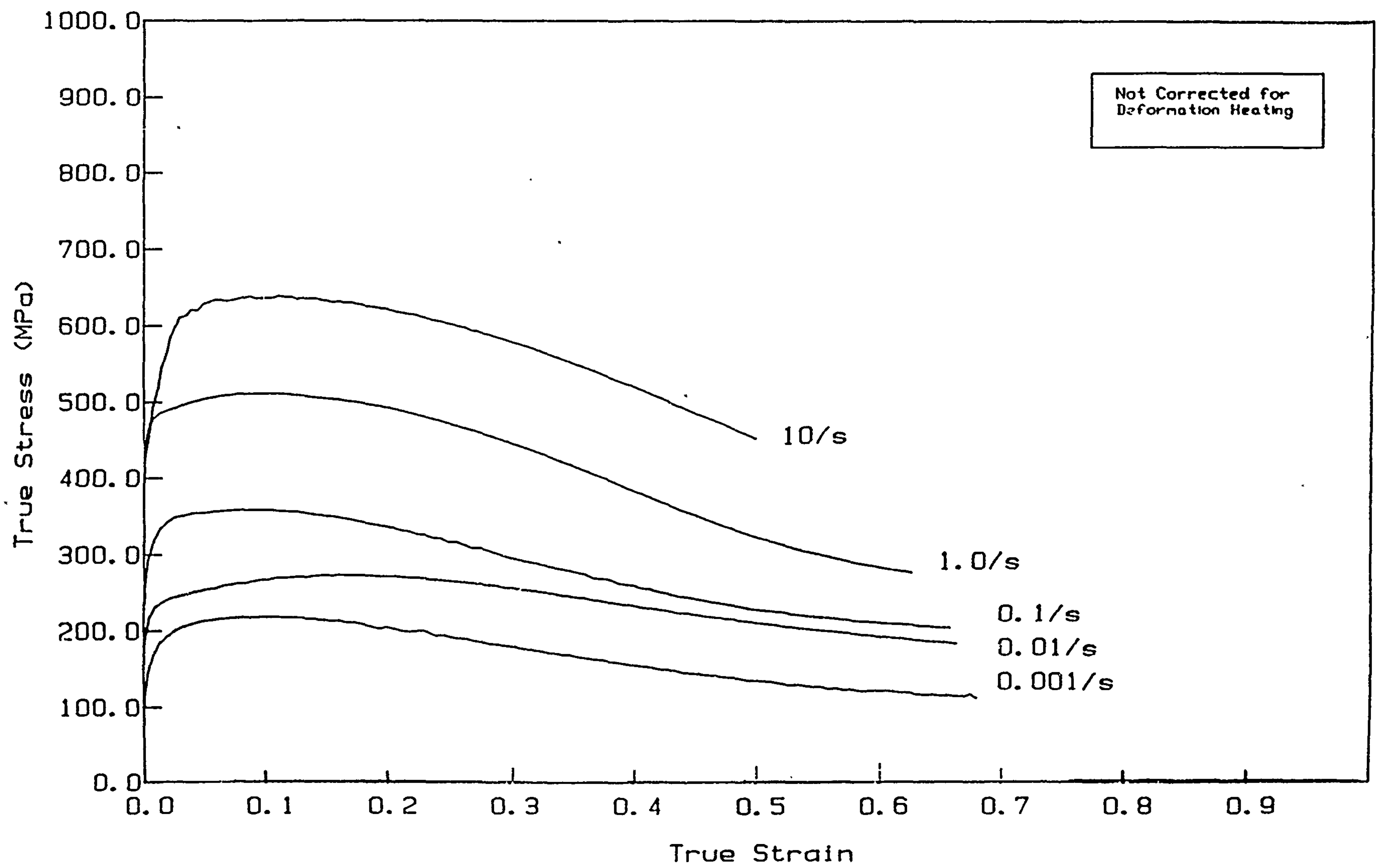


Figure II.A-16. Rene-95 CAP Tested at 1040°C.

TABLE II.A-10: Load Relaxation Tests - Rene-95 CAP

Stress (MPa) at Different Strain Rates (per s)

Strain Rate	CAP95R1 1160°C	CAP95R2 1130°C	CAP95R3 1100°C	CAP95R4 1070°C	CAP95R5 1040°C
1.00E+00	112.980	149.624	200.447	259.418	332.660
1.00E-01	71.285	92.045	109.396	143.219	181.970
3.16E-02	38.459	53.456	65.464	87.096	116.681
1.00E-02	24.547	35.481	42.855	57.280	78.524
3.16E-03	16.982	24.831	30.549	39.994	56.234
1.00E-03	13.996	19.861	23.174	29.717	42.462
3.16E-04	12.359	15.[illegible]36	16.218	20.701	29.444

Load Relaxation Tests - Rene-95 CAP

Log_{10} (Stress) at Different Log_{10} (Strain Rates)

Strain Rate	CAP95R1 1160°C	CAP95R2 1130°C	CAP95R3 1100°C	CAP95R4 1070°C	CAP95R5 1040°C
0.0	2.053	2.175	2.302	2.414	2.522
-1.0	1.853	1.964	2.039	2.156	2.260
-1.5	1.585	1.728	1.816	1.940	2.067
-2.0	1.390	1.550	1.632	1.758	1.895
-2.5	1.230	1.395	1.485	1.602	1.750
-3.0	1.146	1.298	1.365	1.473	1.628
-3.5	1.092	1.180	1.210	1.316	1.469

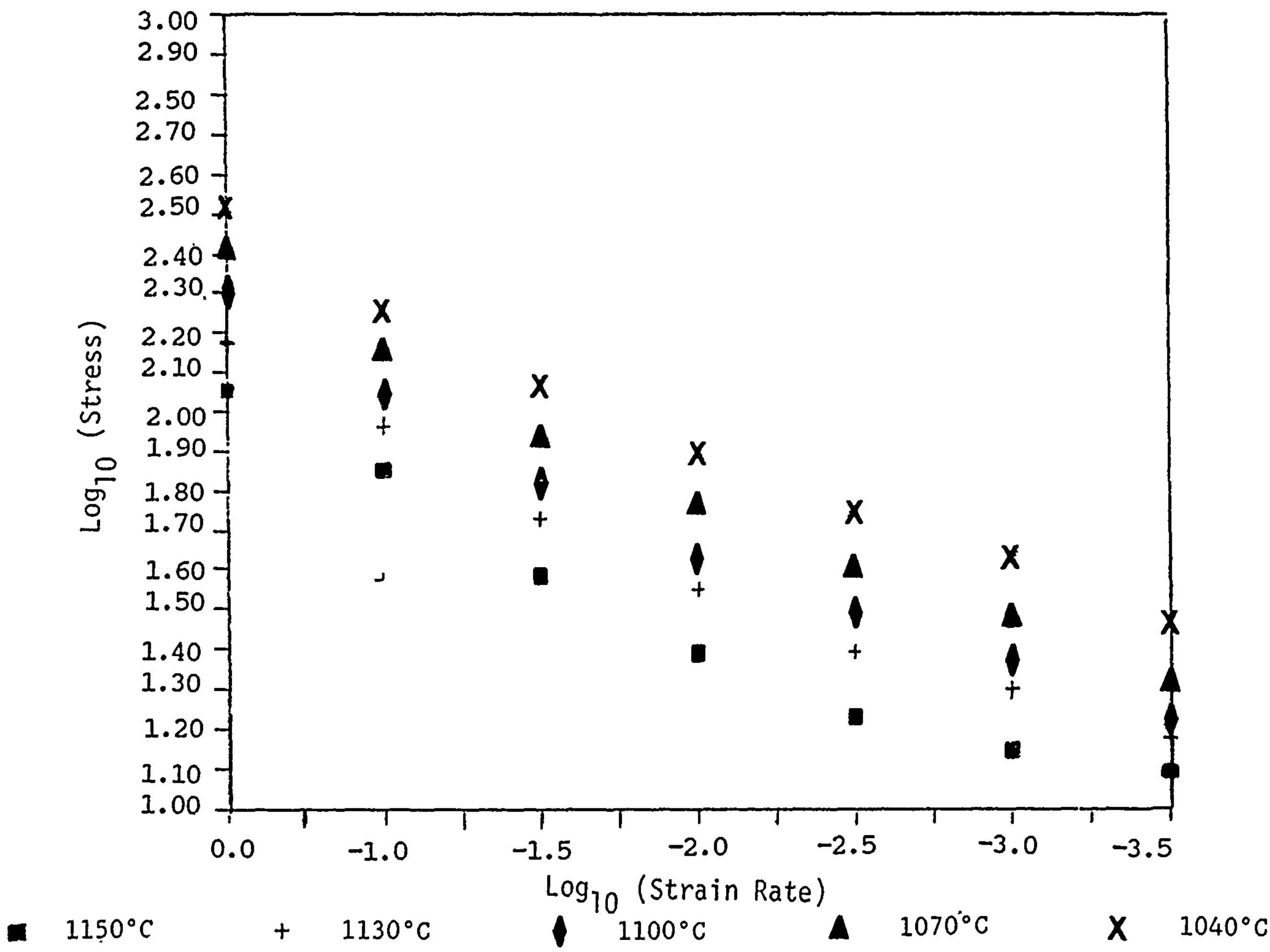


Figure II.A-17. Load Relaxation Tests on Rene-95 CAP at 1150°C, 1130°C, 1100°C, 1070°C, and 1040°C.

TABLE II.A-11: Isoforged TiAl

Test Matrix with Specimen Identification Numbers

Temperature (°C)	10^{-4}	10^{-3}	10^{-2}	10^{-1}	10^{0}
1150		TiAl2 M-27	TiAl3 M-3	TiAl4 M-19	TiAl5 M-5
1200		TiAl7 M-7	TiAl8 M-8	TiAl9 M-20	TiAl10 M-10
1250		TiAl12A M-11	TiAl13 M-1	TiAl14A M-16	TiAl15 M-21
1300		TiAl17 M-18	TiAl18 M-4	TiAl19 M-15	TiAl20 M-12
1350		TiAl22 M-9	TiAl23 M-26	TiAl24 M-14	TiAl25 M-13

Note: Tests at a strain rate of 10^{-4} s^{-1} were not conducted due to the small specimen size.

TABLE II.A-12: Isoforged TiAl Flow Stress Data
Flow Stress in MPa

(Not Corrected for Deformation Heating)

Strain	Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}	10^{0}
0.05	1150	96.280	138.698	263.681	448.344
	1200	52.813	114.325	192.713	384.930
	1250	45.262	83.863	145.464	262.451
	1300	33.249	56.721	94.606	162.511
	1350	17.911	33.038	54.681	94.180
0.10	1150	94.647	140.394	259.274	438.654
	1200	53.811	115.522	186.567	371.797
	1250	45.455	84.768	144.142	251.489
	1300	32.082	55.727	90.475	151.681
	1350	17.127	31.763	51.637	88.812
0.15	1150	91.763	140.625	254.428	428.352
	1200	51.174	115.712	185.723	362.327
	1250	45.589	84.851	142.789	243.360
	1300	30.343	54.684	86.575	143.021
	1350	16.725	30.809	49.215	84.721
0.20	1150	87.453	140.500	250.589	414.468
	1200	52.751	116.556	178.065	352.453
	1250	44.404	85.126	141.518	234.176
	1300	31.052	53.776	83.859	135.622
	1350	17.436	30.210	47.389	79.596
0.25	1150	85.444	138.198	248.645	398.628
	1200	51.790	114.889	177.949	341.011
	1250	43.049	84.470	139.736	225.208
	1300	30.012	52.272	80.557	129.236
	1350	15.971	29.222	45.907	75.767
0.30	1150	82.446	137.271	239.926	3304.212
	1200	50.993	113.644	175.171	330.664
	1250	42.010	83.904	140.129	217.535
	1300	28.774	51.217	80.023	122.873
	1350	15.320	28.484	44.359	71.671

TABLE II.A-13: Isoforged TiAl Flow Stress Data
Flow Stress in MPa

(Not Corrected for Deformation Heating)

Strain	Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}	10^{0}
0.35	1150	80.325	135.420	235.228	368.644
	1200	50.153	111.356	169.955	318.754
	1250	41.156	83.673	138.159	209.196
	1300	29.249	50.467	77.625	117.307
	1350	15.112	27.787	43.291	67.779
0.40	1150	78.882	133.538	232.421	354.259
	1200	48.143	108.869	166.568	308.586
	1250	41.016	82.597	136.436	201.062
	1300	27.922	49.185	75.468	113.082
	1350	14.738	26.966	41.826	65.680
0.45	1150	77.519	131.306	229.965	340.073
	1200	46.812	107.792	163.363	299.505
	1250	41.276	81.280	135.094	193.510
	1300	27.233	48.500	74.473	109.365
	1350	15.103	26.371	41.437	63.307
0.50	1150	76.179	130.664	202.664	327.176
	1200	47.557	105.086	155.086	290.567
	1250	40.137	80.381	134.393	187.089
	1300	27.462	47.859	73.239	105.544
	1350	14.442	25.804	40.711	61.156

TABLE II.A-14: Isoforged TiAl Flow Stress Data
Flow Stress in MPa

(Not Corrected for Deformation Heating)

Strain	Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}	10^{0}
0.05	1150	96.280	139.141	268.994	455.800
	1200	52.813	114.605	195.355	390.055
	1250	45.262	84.106	146.804	268.550
	1300	33.249	56.861	95.475	165.414
	1350	17.911	33.104	55.049	95.278
0.10	1150	94.647	141.306	270.523	454.838
	1200	53.811	116.099	192.037	382.727
	1250	45.455	85.262	146.612	263.832
	1300	32.082	56.023	92.287	157.507
	1350	17.127	31.893	52.349	90.860
0.15	1150	91.763	142.005	270.596	452.809
	1200	51.174	116.585	193.666	378.730
	1250	45.589	85.601	146.576	262.150
	1300	30.343	55.139	89.375	151.778
	1350	16.725	31.001	50.231	87.585
0.20	1150	87.453	142.274	274.223	445.480
	1200	52.751	117.687	189.296	373.312
	1250	44.404	86.149	145.929	259.720
	1300	31.052	54.397	87.651	147.126
	1350	17.436	30.460	48.695	83.234
0.25	1150	85.444	140.364	278.014	434.939
	1200	51.790	116.274	191.916	365.562
	1250	43.049	85.720	145.527	257.353
	1300	30.012	53.058	85.370	143.339
	1350	15.971	29.524	47.454	80.081
0.30	1150	82.446	139.916	272.490	424.911
	1200	50.993	115.330	190.939	358.356
	1250	42.010	85.381	146.619	256.351
	1300	28.774	52.163	85.896	139.661
	1350	15.320	28.836	46.231	76.589

TABLE II.A-15: Isoforged TiAl Flow Stress Data
Flow Stress in MPa

(Not Corrected for Deformation Heating)

Strain	Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}	10^{0}
0.35	1150	80.325	138.580	274.582	413.046
	1200	50.153	113.356	188.749	349.128
	1250	41.156	85.297	145.141	254.430
	1300	29.249	51.577	84.530	136.522
	1350	15.112	28.191	45.391	73.269
0.40	1150	78.882	137.262	279.061	400.661
	1200	48.143	111.201	188.555	340.608
	1250	41.016	84.372	144.083	253.360
	1300	27.922	50.448	83.429	124.445
	1350	14.738	27.414	44.160	71.666
0.45	1150	77.519	135.284	284.666	386.111
	1200	46.812	110.298	188.770	331.703
	1250	41.276	83.293	143.254	253.370
	1300	27.233	49.891	83.456	132.759
	1350	15.103	26.866	44.013	69.812
0.50	1150	76.178	135.464	297.720	373.492
	1200	47.557	108.348	185.987	323.157
	1250	40.137	82.504	141.179	254.296
	1300	27.462	49.384	83.377	131.141
	1350	14.442	26.345	43.523	68.102

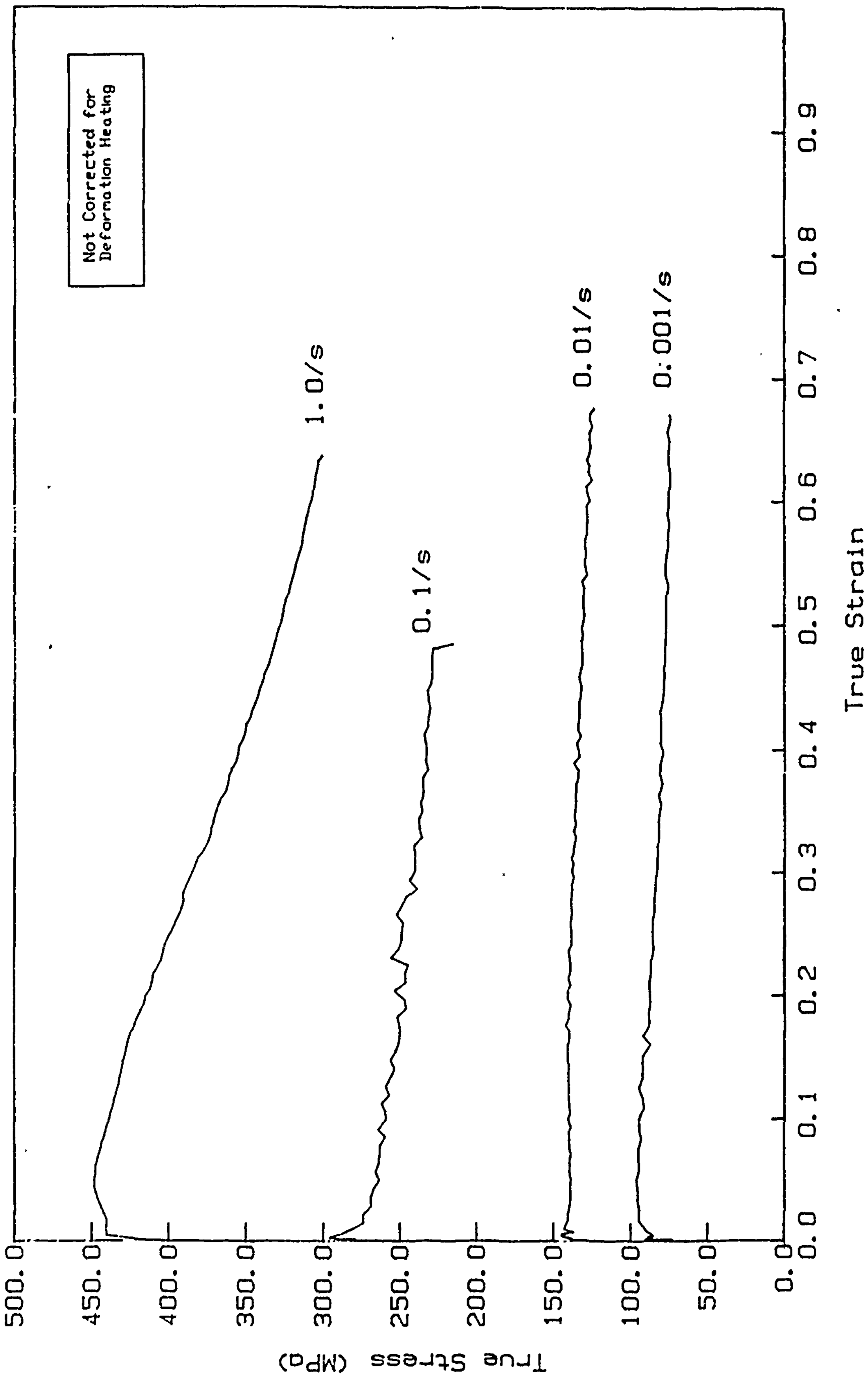


Figure II.A-18. Isoforged TiAl Tested at 1150°C.

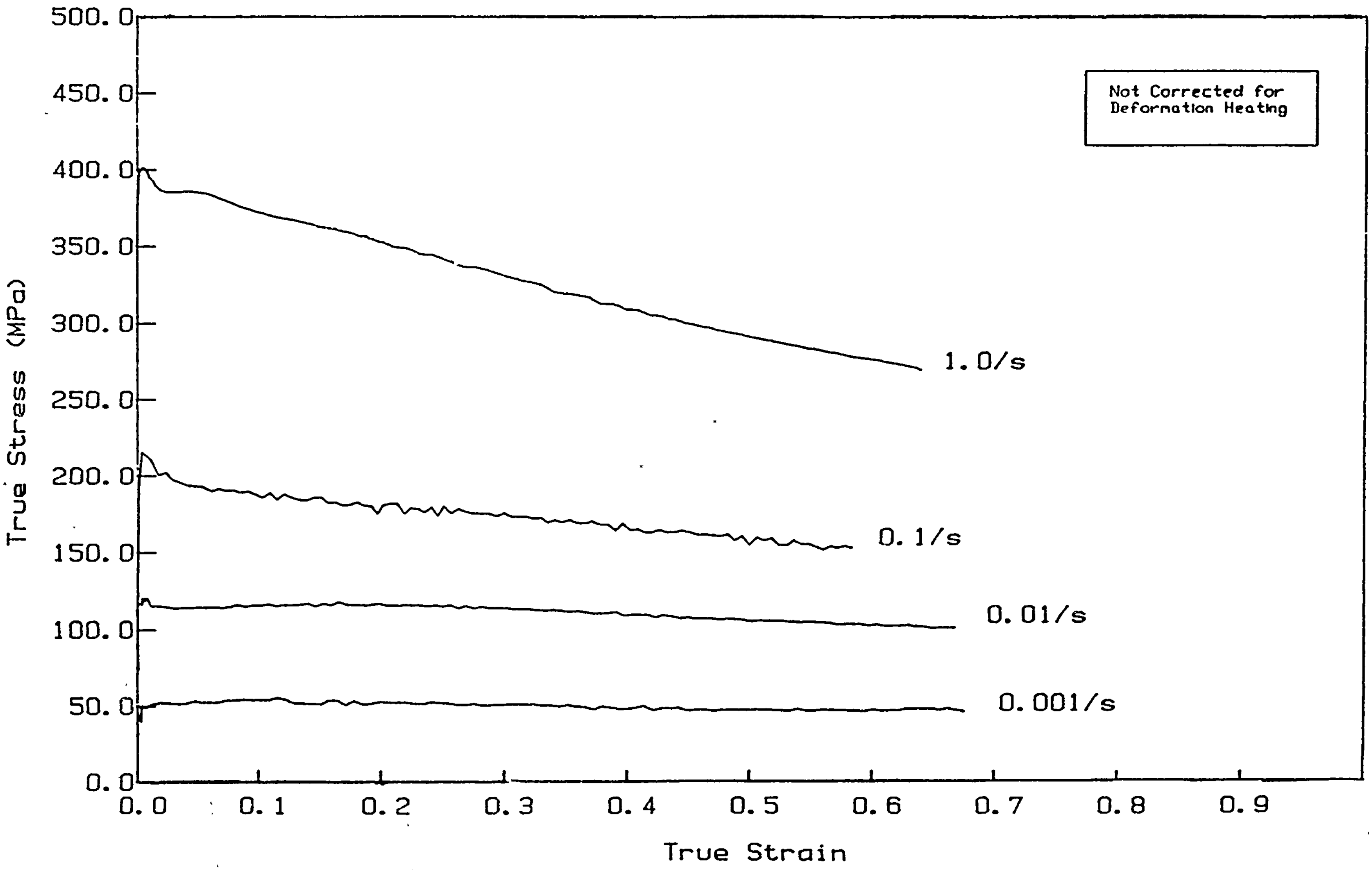


Figure II.A-19. Isoforged TiAl Tested at 1200°C.

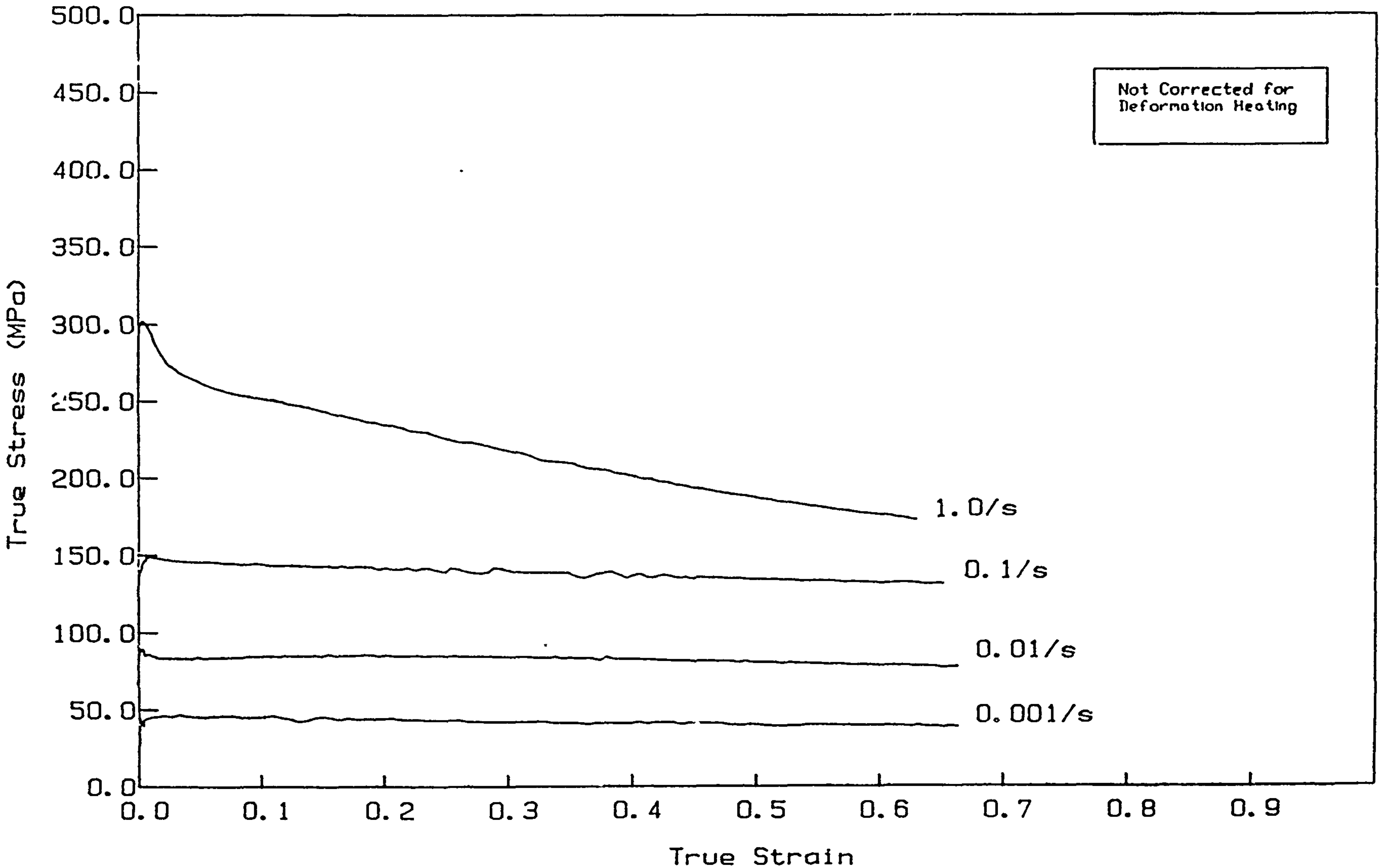


Figure II.A-20. Isoforged TiAl Tested at 1250°C.

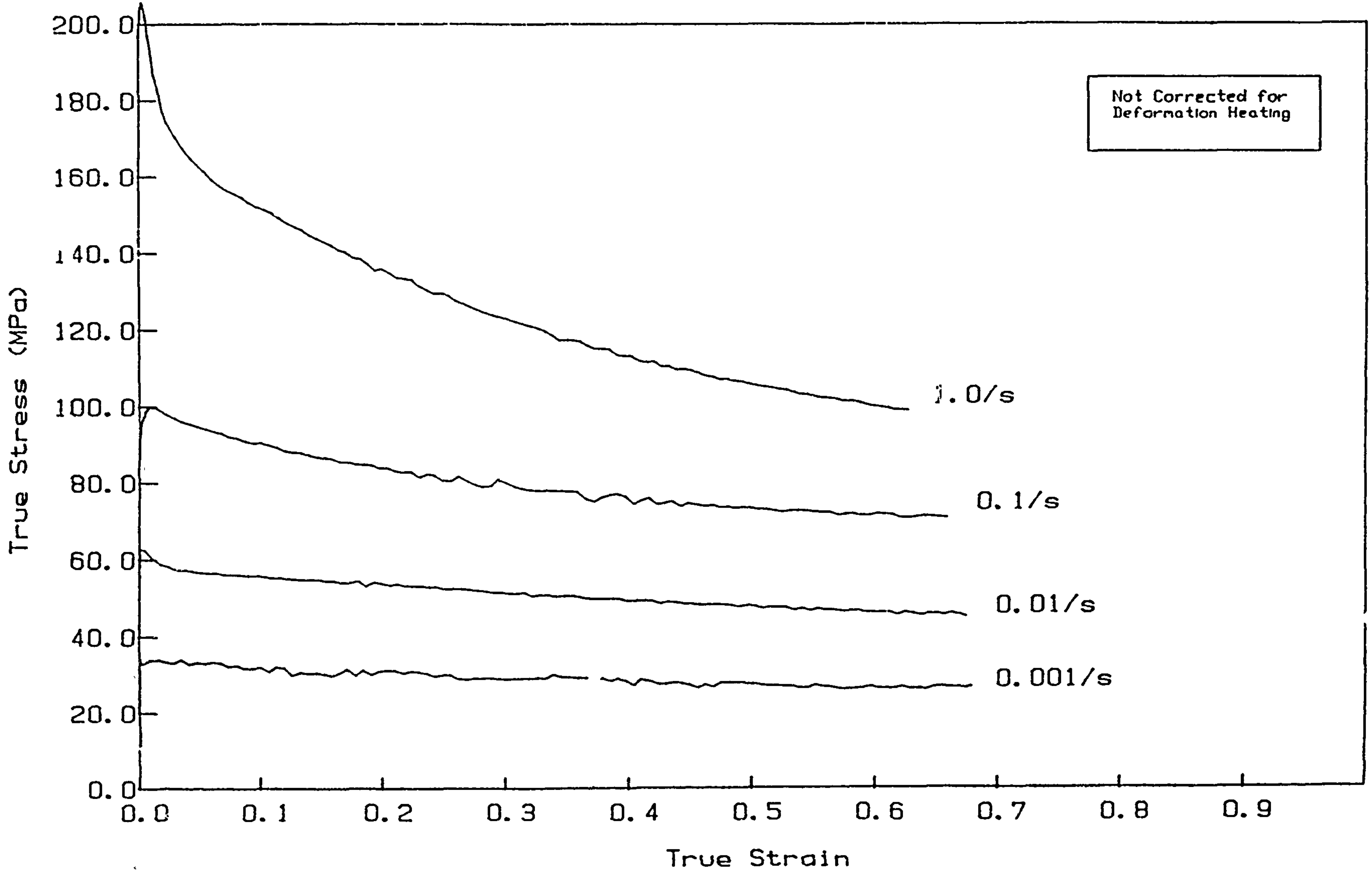


Figure II.A-21. Isoforged TiAl Tested at 1300°C.

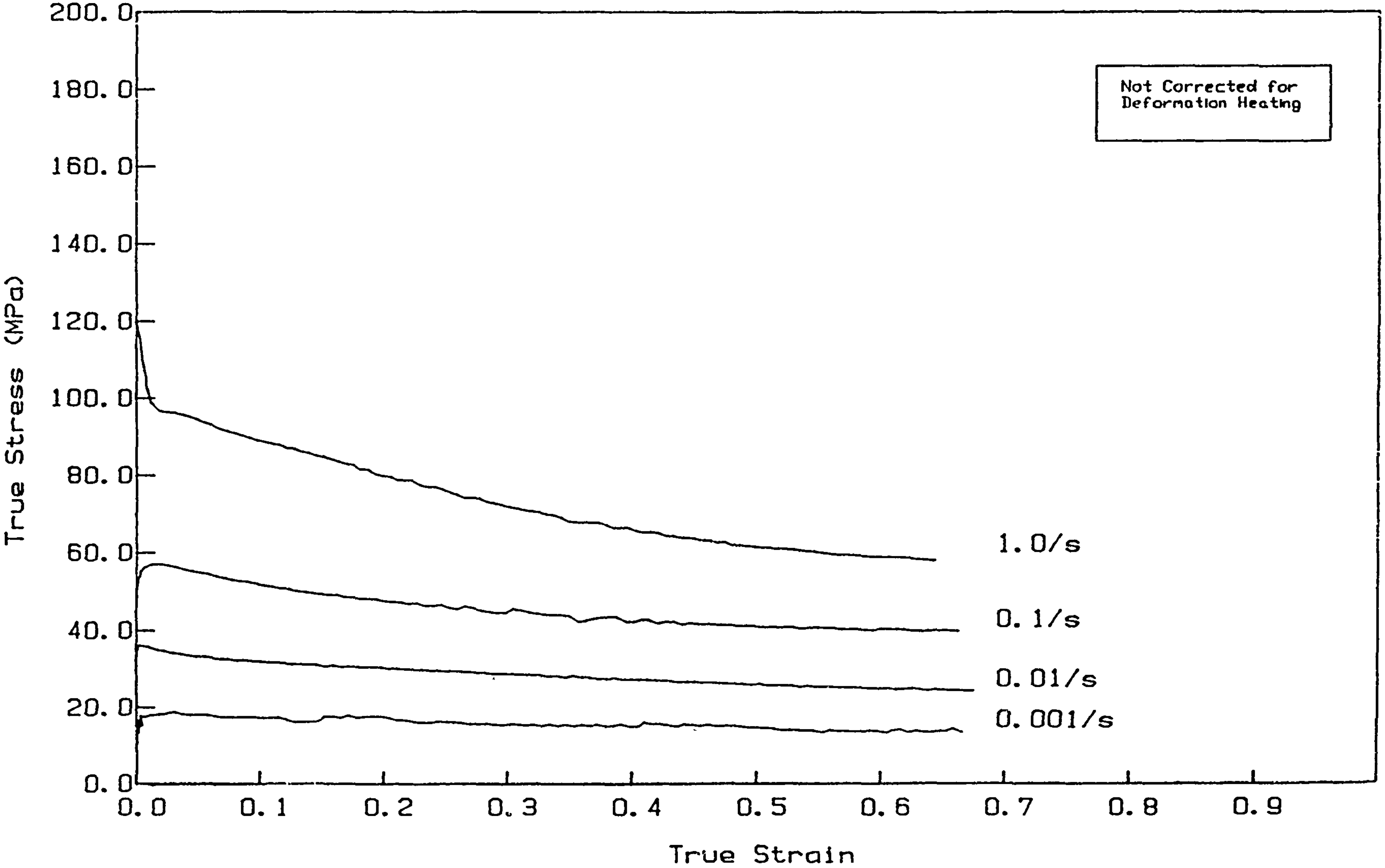


Figure II.A-22. Isoforged TiAl Tested at 1350°C.

TABLE II.A-16: Liquid Phase Sintered Tungsten

Constant Strain-Rate Compression Tests
Strain-rate: 0.01 in./in./s

Strain	Flow Stress in Ksi	
	697°C	798°C
0.02	61.63	57.76
0.04	70.53	83.71
0.06	77.15	68.08
0.80	82.04	71.08
0.10	85.96	73.58
0.12	89.17	75.43
0.14	91.63	77.12
0.16	93.86	78.34
0.18	95.47	79.46
0.20	96.94	79.95
0.22	97.99	80.52
0.24	98.98	81.09
0.26	99.82	80.88
0.28	100.23	80.76
0.30	100.59	80.76
0.32	100.84	80.45
0.34	100.52	80.55
0.36	100.23	80.14
0.38	100.01	79.68
0.40	99.51	79.51
0.42	99.02	78.95
0.44	98.43	78.45
0.46	97.70	77.82
0.48	96.50	77.34
0.50	95.57	76.57
0.52	94.48	75.75
0.54	93.19	75.43
0.5S	92.23	74.17
0.58	90.74	73.59
0.60	89.69	71.88

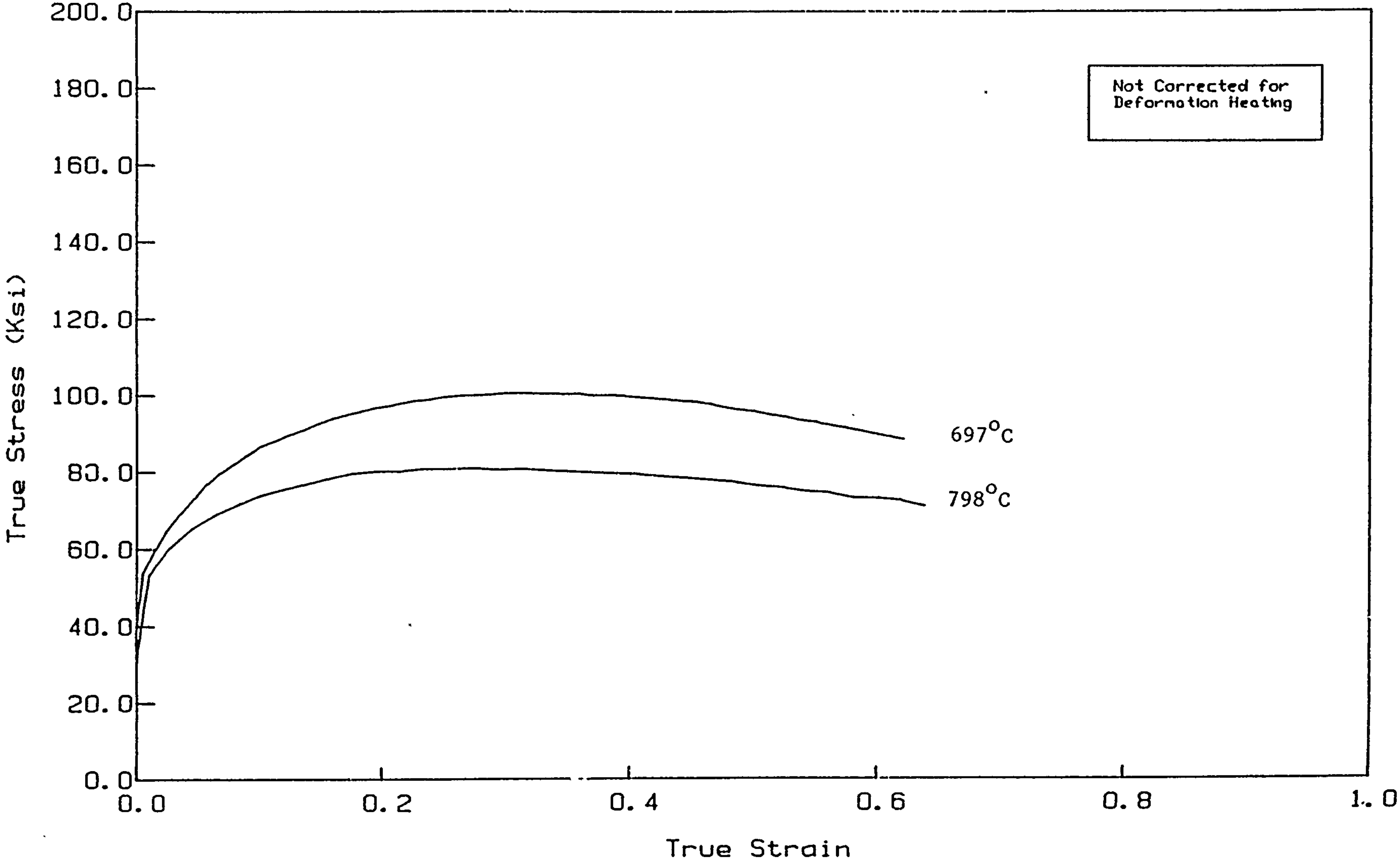


Figure II.A-23. Liquid Phase Sintered Tungsten Tested at a Strain Rate of 0.01 in/in/s.

TABLE II.A-17: Ti-15V-3Al-3Cr-3Sn Test Matrix
First Generation Tests
As-Cast Microstructure

Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}
843	W17	W4	W2
927	W11	W12	W13
1010	W9	W7	W8
1093	W10	W3	W1
1177	W14	W5	W6
1260	W18	W16	W15

TABLE II.A-18: Ti-15V-3Al-3Cr-3Sn Flow Stress
Flow Stress in MPa

(Not Corrected for Deformation Heating)

Strain	Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}
0.05	843	65.017	119.122	174.514
	927	49.241	92.342	142.363
	1010	27.300	52.645	90.444
	1093	18.073	38.441	73.543
	1177	10.409	24.750	53.994
	1260	8.061	21.959	43.860
0.10	843	68.370	119.596	168.192
	927	51.116	92.621	140.792
	1010	28.765	52.832	89.185
	1093	18.607	38.662	72.947
	1177	10.623	24.090	53.657
	1260	8.305	21.358	43.327
0.15	843	70.194	119.640	162.747
	927	52.110	94.101	138.782
	1010	28.774	52.322	88.082
	1093	17.812	38.303	71.723
	1177	10.616	23.752	53.332
	1260	8.003	20.892	42.565
0.20	843	70.822	119.938	156.623
	927	51.373	93.341	136.846
	1010	28.605	52.472	87.308
	1093	17.740	37.090	70.821
	1177	10.478	24.163	52.363
	1260	8.217	20.493	41.670
0.25	843	70.773	119.375	150.687
	927	50.339	92.962	133.831
	1010	27.877	53.042	85.081
	1093	17.179	36.808	69.258
	1177	10.346	23.941	51.064
	1260	7.927	20.167	40.922

TABLE II.A-19: Ti-15V-3Al-3Cr-3Sn Flow Stress
Flow Stress in MPa

(Not Corrected for Deformation Heating)

Strain	Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}
0.30	843	70.445	115.571	144.805
	927	49.847	92.422	131.767
	1010	27.091	52.705	84.270
	1093	16.814	36.134	68.080
	1177	10.228	24.185	51.290
	1260	8.069	19.883	40.164
0.35	843	68.387	113.999	138.160
	927	47.477	91.564	129.733
	1010	26.702	52.088	83.764
	1093	16.820	35.864	66.702
	1177	10.159	23.575	50.134
	1260	7.566	19.607	39.436
0.40	843	67.172	111.798	133.754
	927	46.970	90.951	127.614
	1010	25.813	52.015	83.561
	1093	16.568	35.439	65.582
	1177	10.067	23.347	48.975
	1260	8.096	19.374	38.411
0.45	843	67.352	109.671	132.539
	927	45.604	89.980	125.422
	1010	25.400	52.149	83.686
	1093	16.003	35.005	64.018
	1177	9.946	23.338	48.091
	1260	8.081	19.065	37.609
0.50	843	66.111	108.029	132.086
	927	44.919	88.689	123.804
	1010	24.634	51.934	83.247
	1093	16.401	34.840	62.763
	1177	9.873	23.106	47.485
	1260	7.875	18.851	36.981

TABLE II.A-20: Ti-15V-3Al-3Cr-3Sn Flow Stress
Flow Stress in MPa

(Not Corrected for Deformation Heating)

Strain	Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}
0.05	843	65.017	119.310	175.161
	927	49.241	92.440	142.734
	1010	27.300	52.716	90.786
	1093	18.073	38.462	73.645
	1177	10.409	24.762	54.076
	1260	8.061	21.961	43.897
0.10	843	68.370	119.976	169.277
	927	51.116	92.818	141.436
	1010	28.765	52.976	89.866
	1093	18.607	38.705	73.146
	1177	10.623	24.115	53.819
	1260	8.305	21.364	43.402
0.15	843	70.194	120.177	164.143
	927	52.110	94.385	139.635
	1010	28.774	52.545	89.089
	1093	17.812	38.366	72.021
	1177	10.616	23.790	53.566
	1260	8.003	20.900	42.681
0.20	843	70.822	120.691	158.123
	927	51.373	93.737	137.794
	1010	28.605	52.766	88.626
	1093	17.740	37.180	71.221
	1177	10.478	24.209	52.675
	1260	8.217	20.507	41.822
0.25	843	70.773	120.310	152.251
	927	50.339	93.453	134.845
	1010	27.877	53.405	86.701
	1093	17.179	36.926	69.736
	1177	10.346	23.998	51.446
	1260	7.927	20.184	41.102

TABLE II.A-21: Ti-15V-3Al-3Cr-3Sn Flow Stress Data
Flow Stresses in MPa

(Not Corrected for Deformation Heating)

Strain	Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}
0.30	843	70.445	116.542	146.216
	927	49.847	92.945	132.715
	1010	27.091	53.140	86.171
	1093	16.S14	36.277	68.661
	1177	10.228	24.249	51.716
	1260	8.069	19.906	40.397
0.35	843	68.387	115.091	139.190
	927	47.477	92.157	130.454
	1010	26.702	52.592	85.923
	1093	16.820	36.027	67.408
	1177	10.159	23.652	50.622
	1260	7.566	19.632	39.696
0.40	843	67.172	112.946	134.590
	927	46.970	91.585	128.215
	1010	25.813	52.586	85.947
	1093	16.568	35.627	66.421
	1177	10.067	23.433	49.530
	1260	8.096	19.401	38.702
0.45	843	67.352	110.879	133.619
	927	45.604	90.656	126.199
	1010	25.400	52.779	86.260
	1093	16.003	35.220	65.032
	1177	9.946	23.431	48.688
	1260	8.081	19.098	37.931
0.50	843	66.111	109.340	133.472
	927	44.919	89.426	124.799
	1010	24.634	52.619	86.045
	1093	16.401	35.078	63.921
	1177	9.873	23.210	48.121
	1260	7.875	18.888	37.336

TABLE II.A-22: Second and Third Generation Tests

Test No.	Specimen Origin	Strain Rate (s^{-1})	Temperature (°C)
W2-A	W2	10^{-1}	843
W2-B	W2	10^{-1}	843
W2-C	W2	10^{-1}	1177
W2-AA	W2-A	10^{-1}	843
W2-AB	W2-A	10^{-1}	843
W6-A	W6	10^{-1}	1177
W6-B	W6	10^{-1}	1177
W6-C	W6	10^{-1}	843
W6-AA	W6-A	10^{-1}	1177
W6-AB	W6-A	10^{-1}	1177
W8-A	W8	10^{-1}	1010
W8-B	W8	10^{-1}	1010

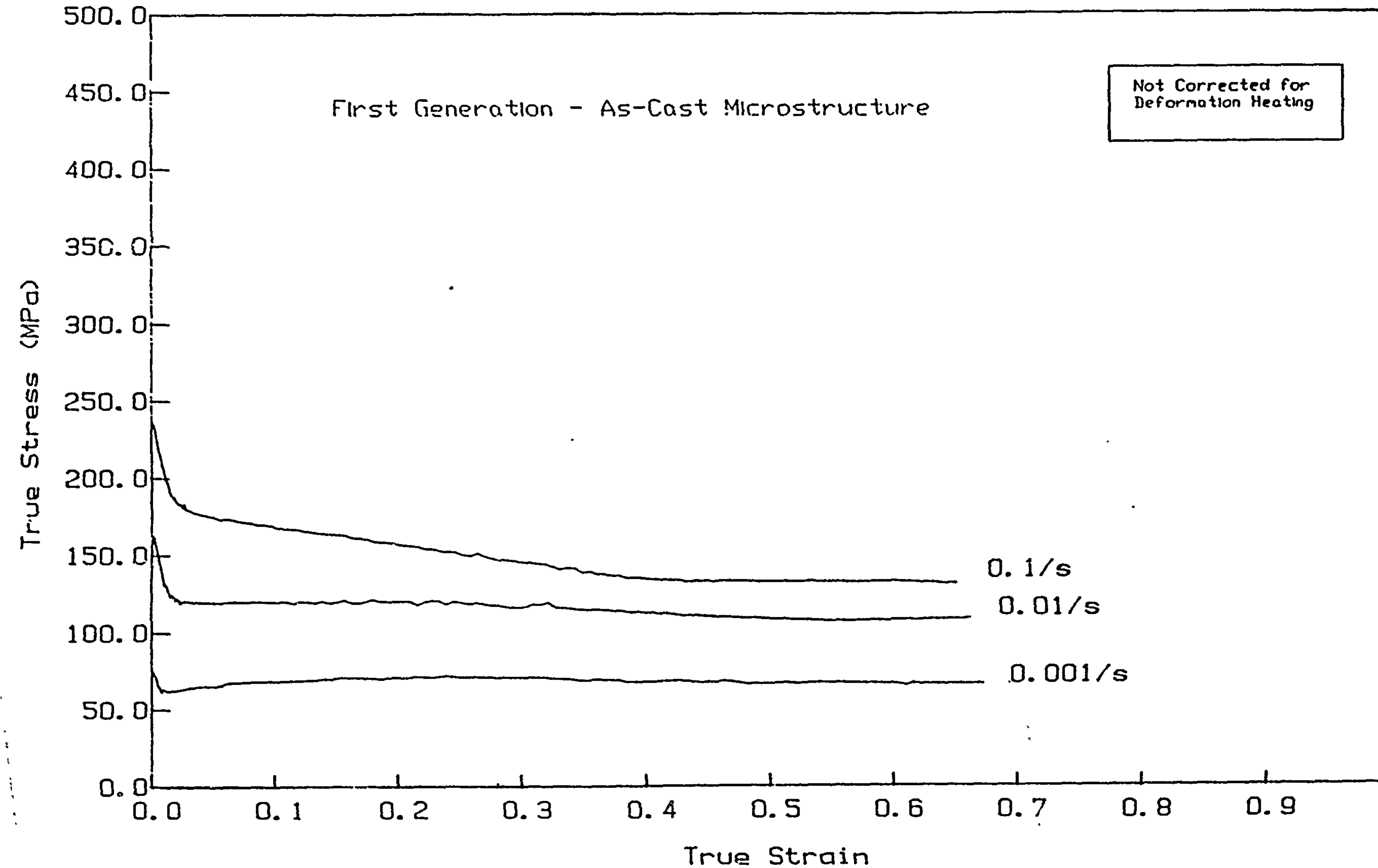


Figure II.A-24. Ti-15V-3Al-3Cr-3Sn Tested at 843°C.

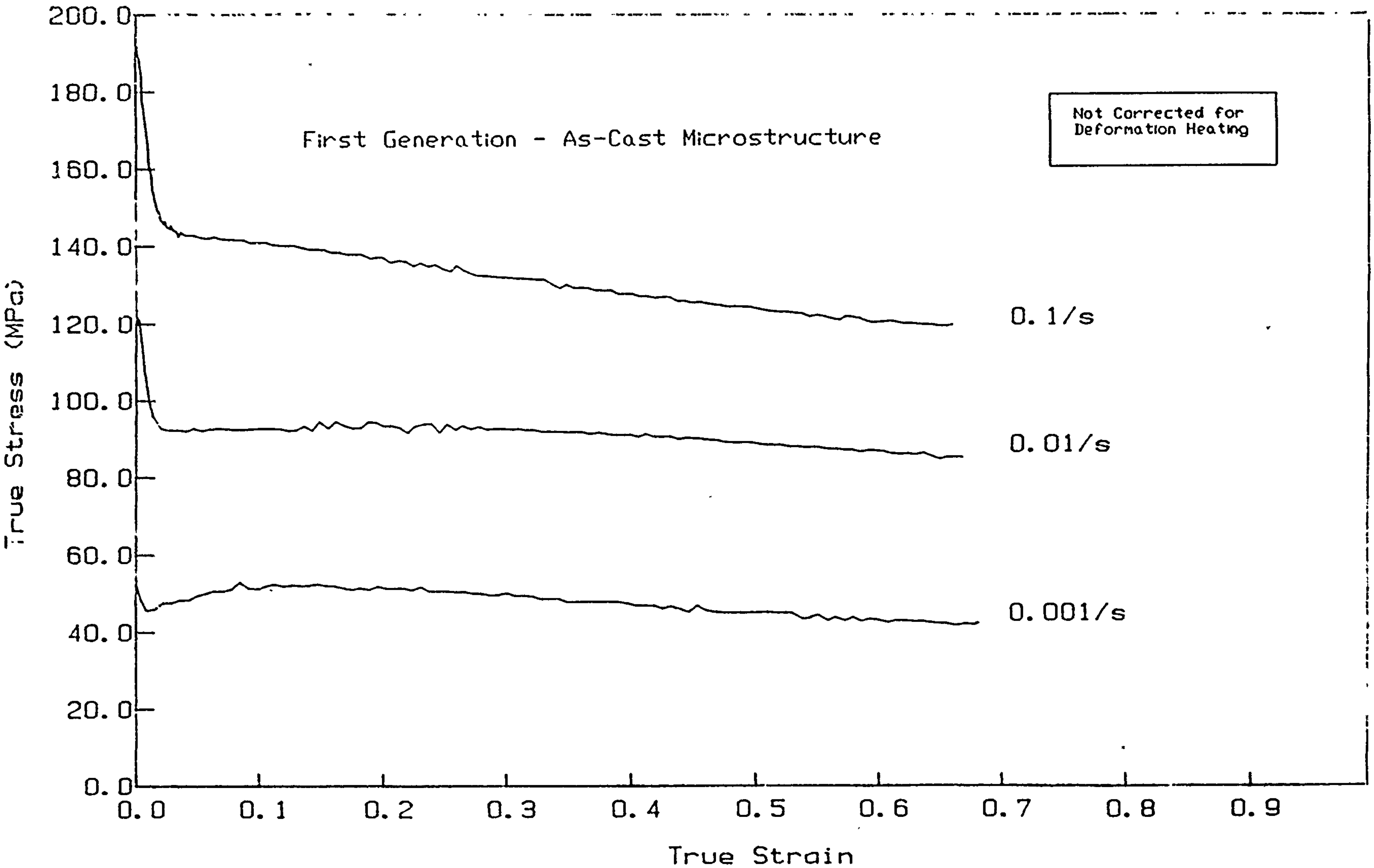


Figure II.A-25. Ti-15V-3Al-3Cr-3Sn Tested at 927°C.

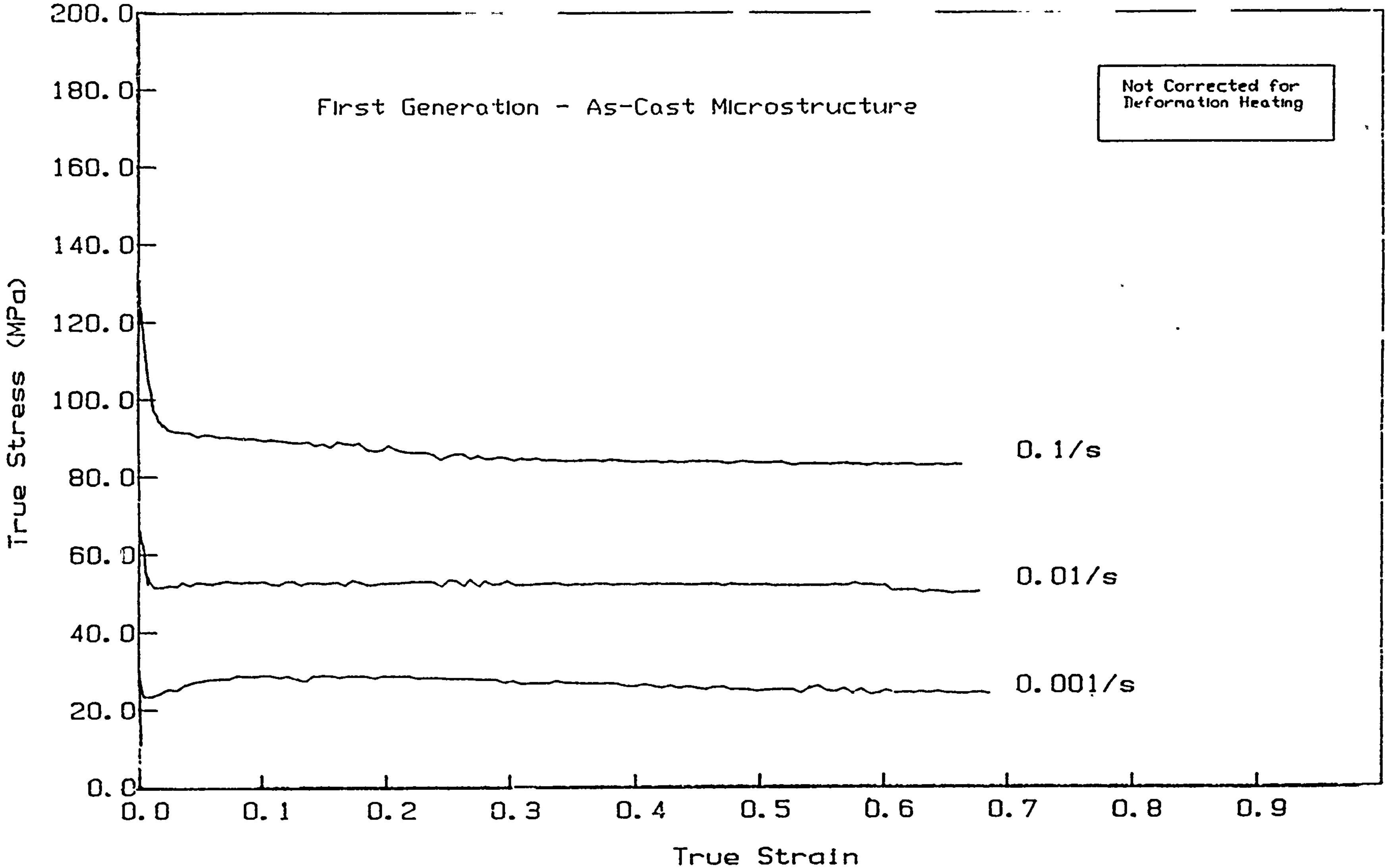


Figure II.A-26. Ti-15V-3Al-3Cr-3Sn Tested at 1010°C.

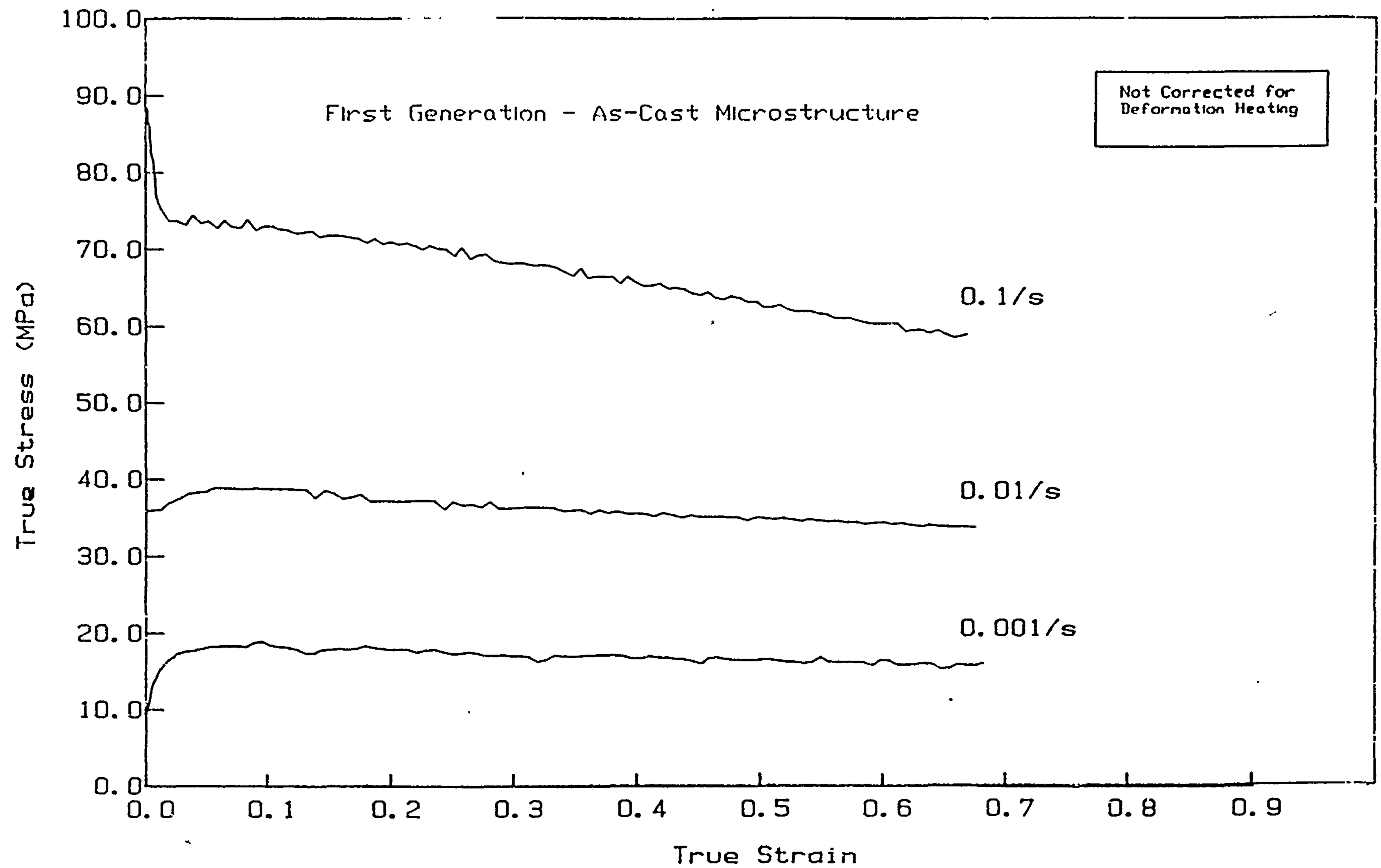


Figure II.A-27. Ti-15V-3Al-3Cr-3Sn Tested at 1093°C.

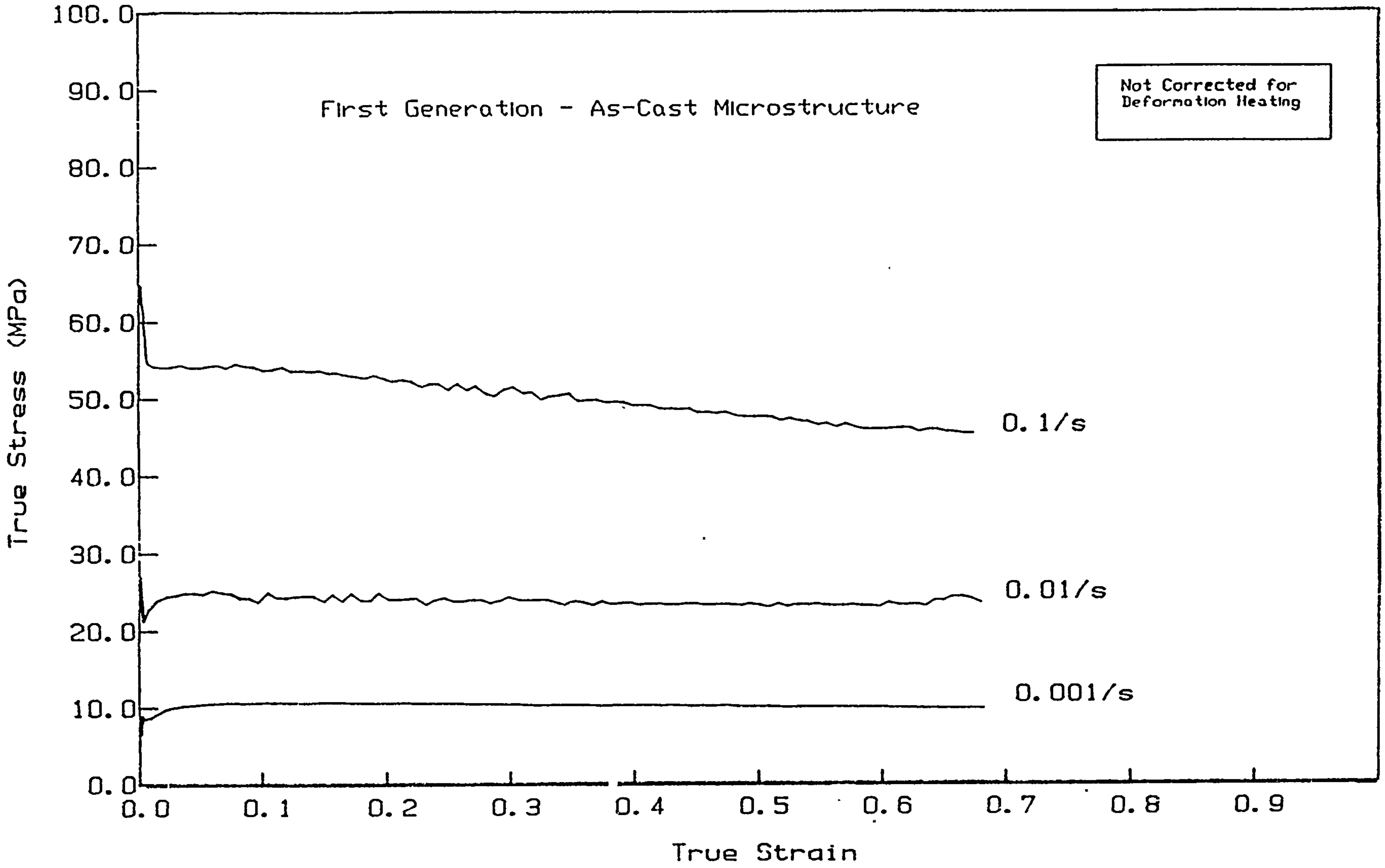


Figure II.A-28. Ti-15V-3Al-3Cr-3Sn Tested at 1177^{o}C.

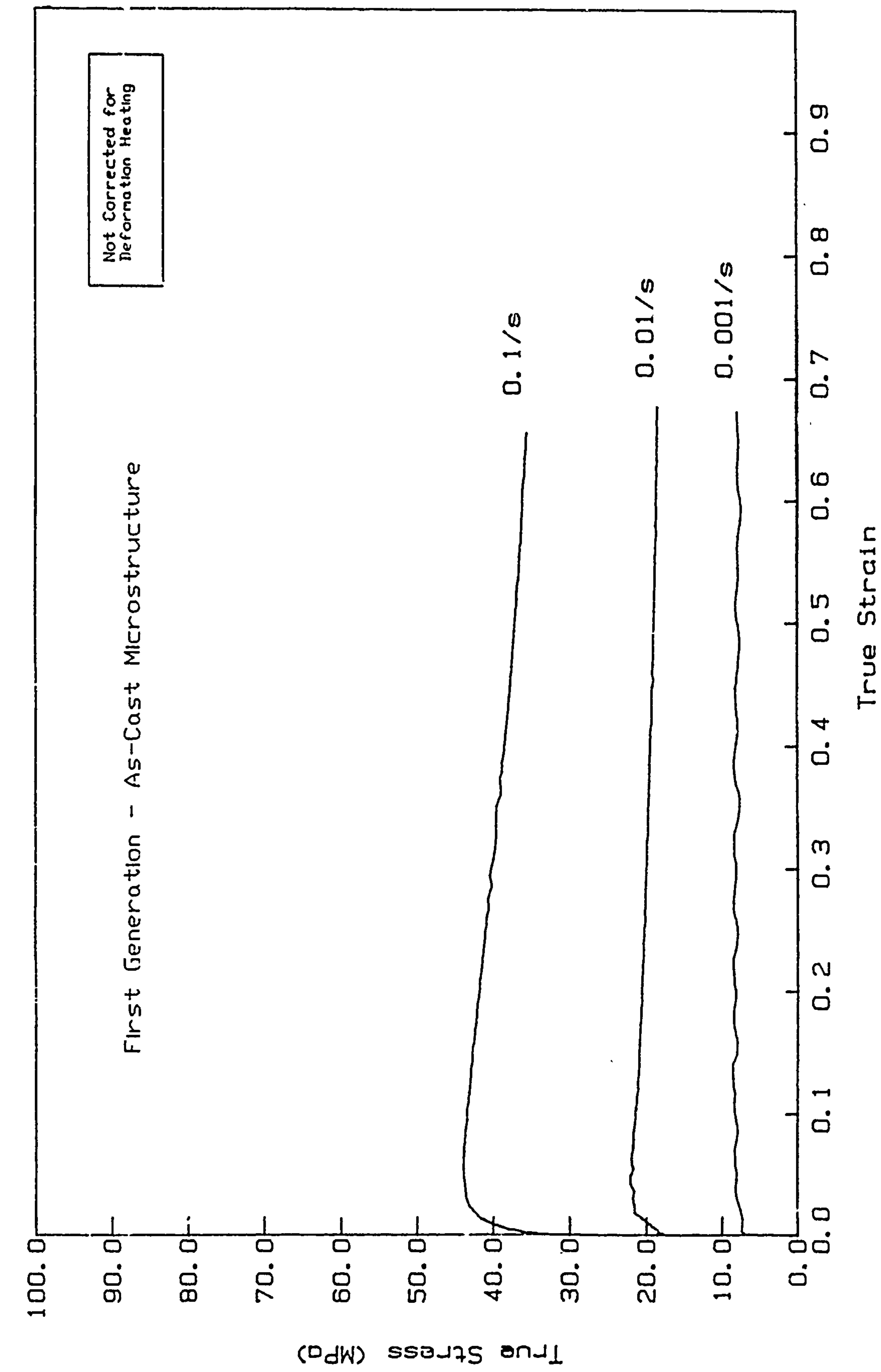


Figure II.A-29. Ti-15V-3Al-3Cr-3Sn Tested at 1260°C.

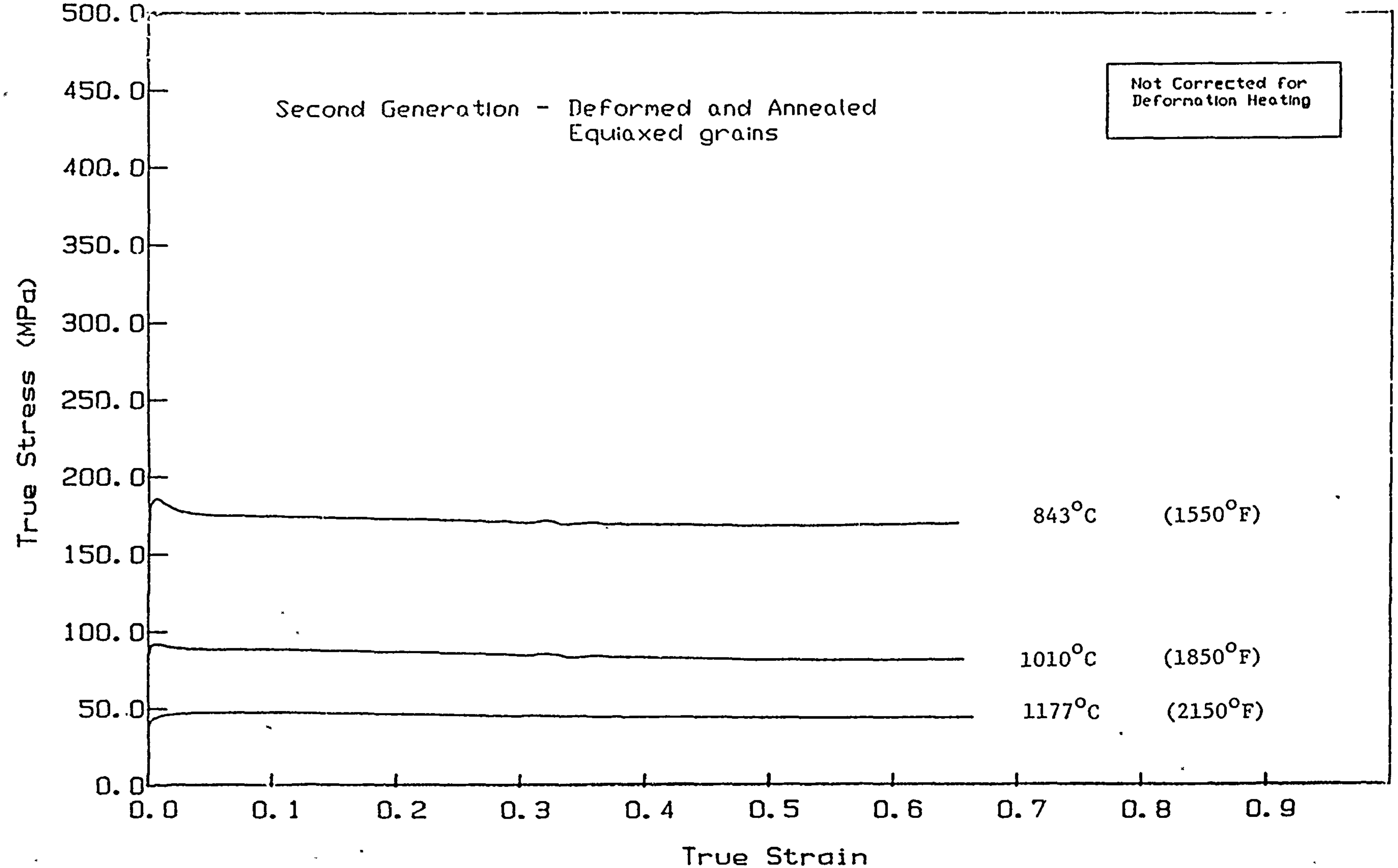


Figure II.A-30. Ti-15V-3Al-3Cr-3Sn Tested at a Strain Rate of 0.1/s.

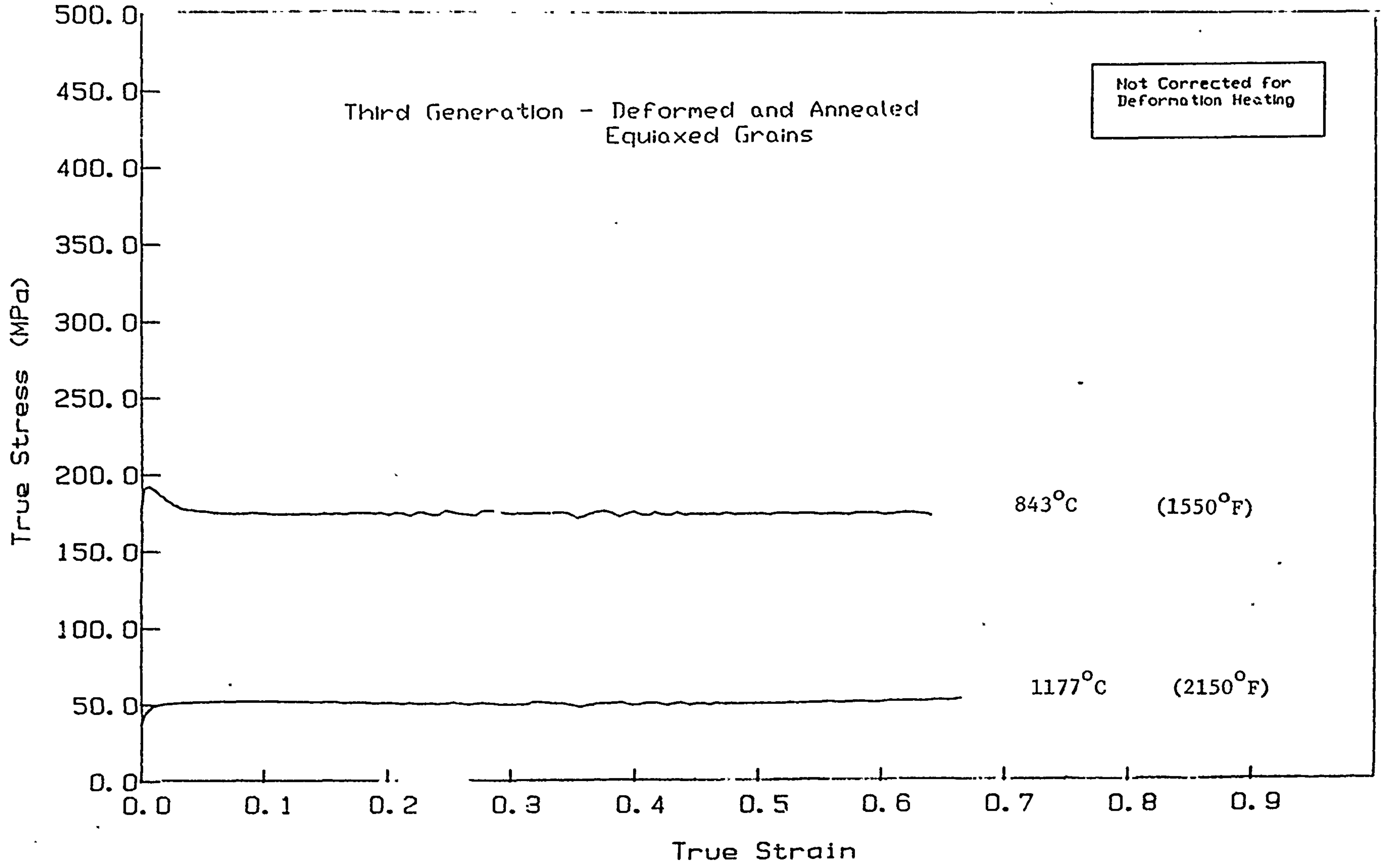


Figure II.A-31. Ti-15V-3Al-3Cr-3Sn Tested at a Strain Rate of 0.1/s.

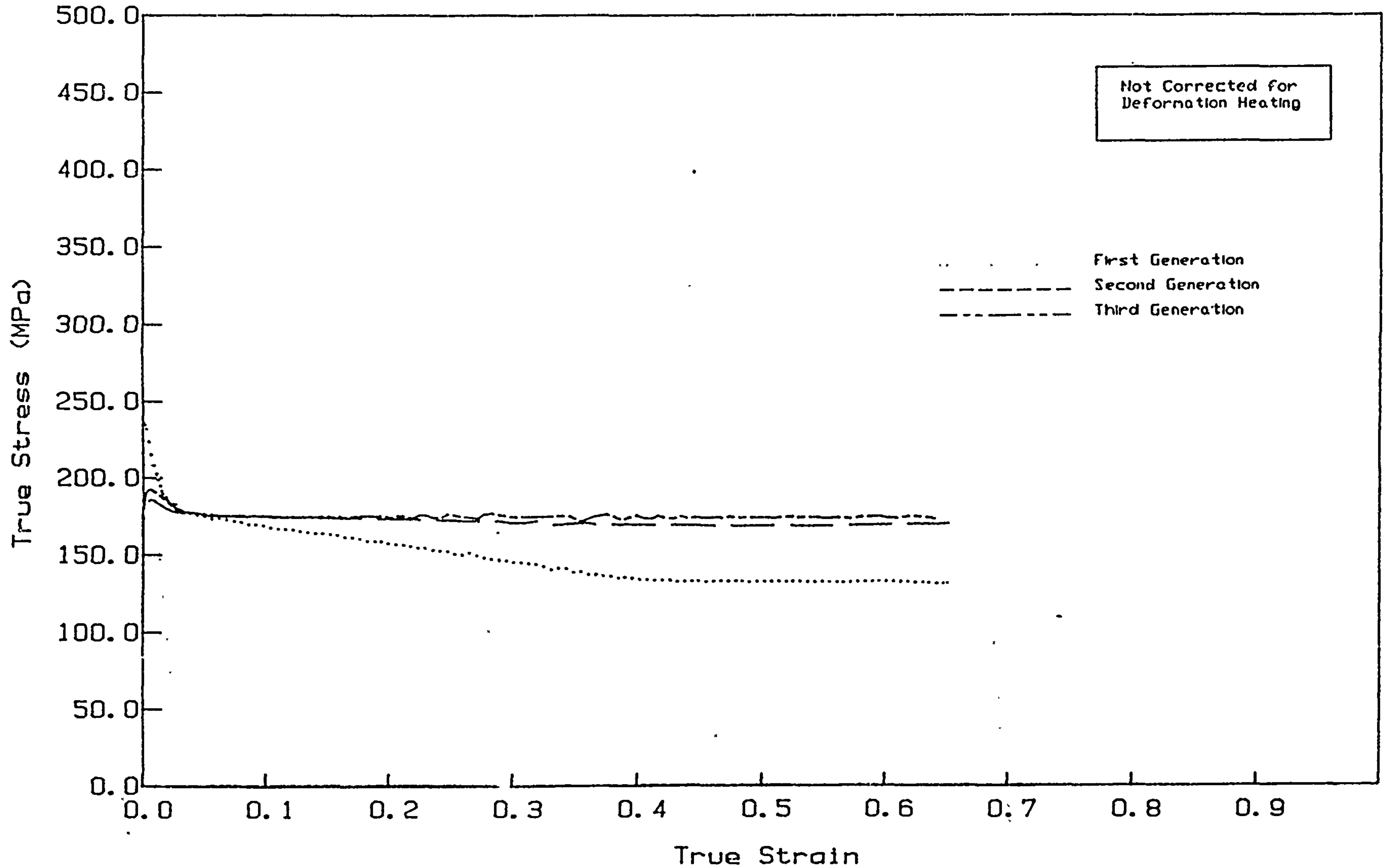


Figure II.A-32. Ti-15V-3Al-3Cr-3Sn Tested at a Strain Rate of 0.1/s and 843°C.

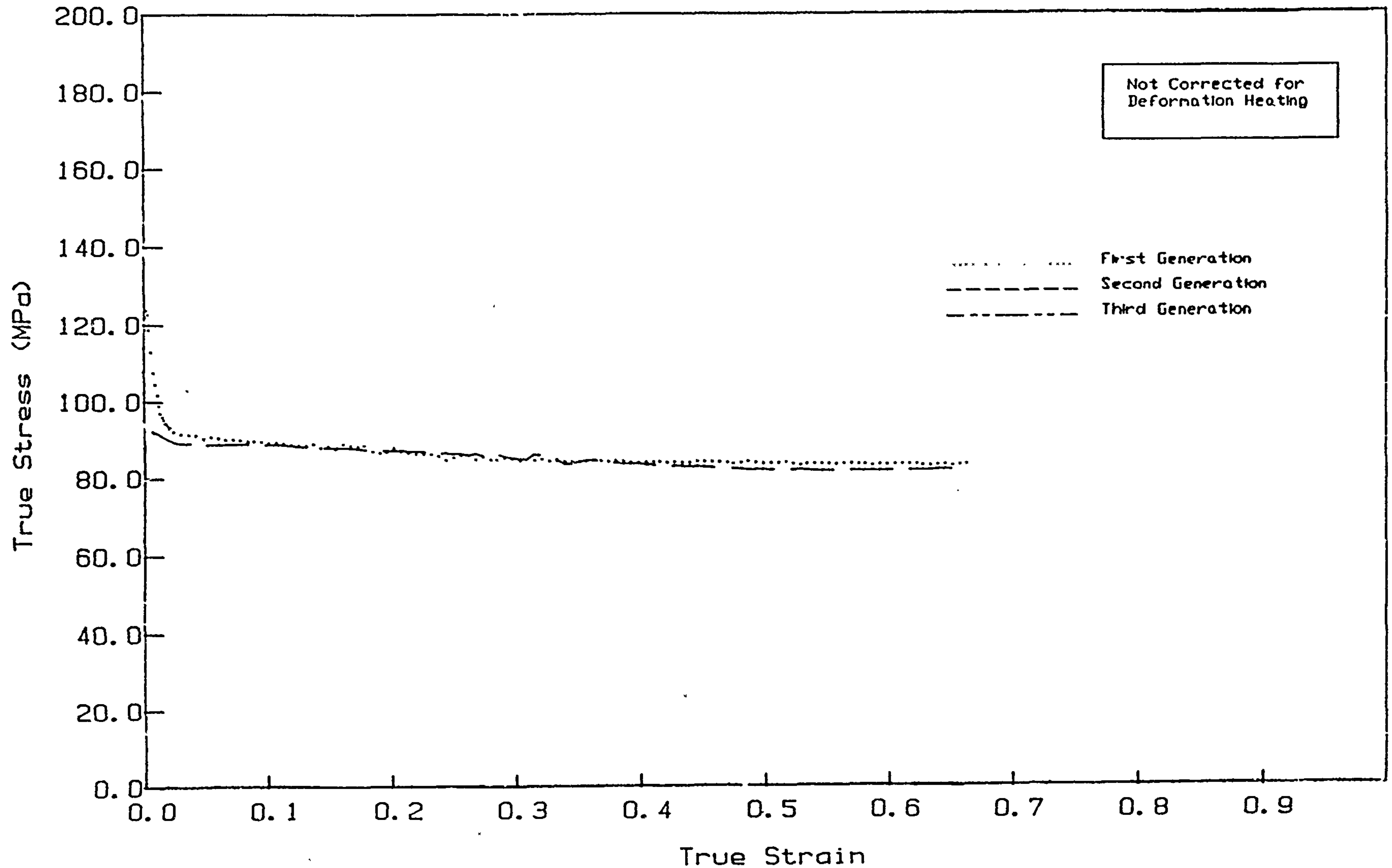


Figure II.A-33. Ti-15V-3Al-3Cr-3Sn Tested at a Strain Rate of 0.1 s and 1010°C

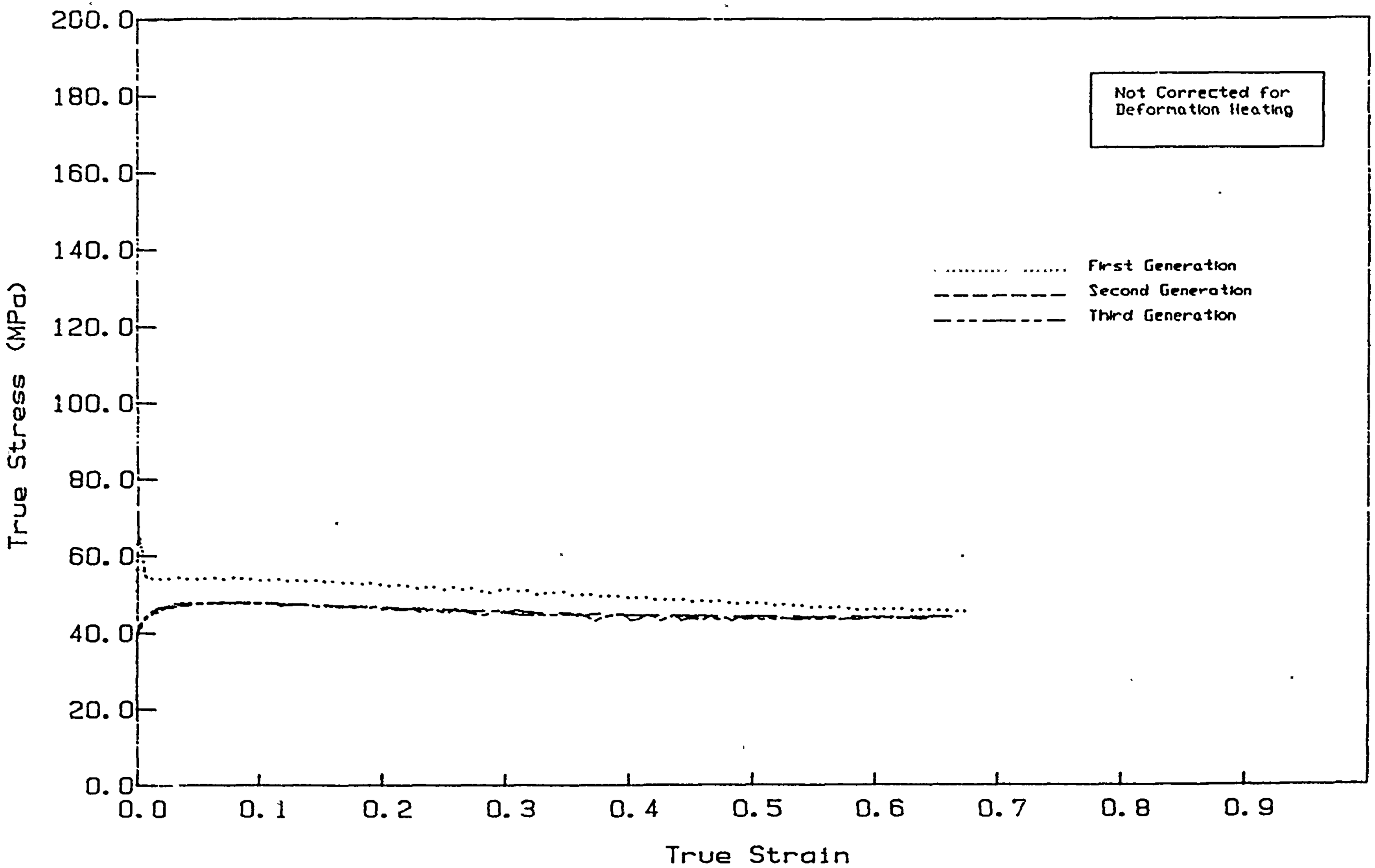


Figure II.A-34. Ti-15V-3Al-3Cr-3Sn Tested at a Strain Rate of 0.1 s and 1177°C.

TABLE II.A-23: Ti-6Al-7Sn-4Zr-0.2Si
Test Matrix

Temperature (°C)	Strain Rate (s^{-1})				
	10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}
800	T674N1	T674N2	T674N3	T674N4	T674N5
850	T674N6	T674N7	T674N8	T674N9	T674N10
900	T674N11	T674N12	T674N13	T674N14	T674N15
950	T674N16	T674N17	T674N18	T674N19	T674N20
1000	T674N21	T674N22	T674N23	T674N24	T674N25
1050	T674N26	T674N27	T674N28	T674N29	T674N30

TABLE II.A-24: Ti-6Al-7Sn-4Zr-0.2Si Flow Stress Data
Flow Stress in MPA

(Not Corrected for Deformation Heating)

Strain	Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}
0.05	800	399.949	463.763	564.233	591.903	270.148
	850	268.541	350.423	467.167	550.977	284.630
	900	175.743	258.067	359.568	475.837	511.344
	950	116.125	161.403	258.909	384.347	422.120
	1000	11.438	22.952	39.143	84.248	125.351
	1050	7.714	18.932	37.256	69.666	114.351
0.10	800	429.083	491.410	566.376	644.044	298.604
	850	290.167	372.432	461.536	576.105	310.110
	900	194.643	271.561	347.534	461.094	525.932
	950	124.017	168.598	244.552	354.256	366.508
	1000	11.758	22.689	39.138	84.223	126.914
	1050	8.119	18.902	38.246	72.347	117.880
0.15	800	442.142	507.327	552.092	655.603	319.717
	850	298.846	383.927	446.757	568.785	313.779
	900	205.592	281.725	334.195	436.391	511.799
	950	128.567	175.360	230.619	322.011	328.202
	1000	12.170	22.649	39.347	83.884	127.433
	1050	7.987	19.446	39.009	73.668	118.199
0.20	800	446.109	511.643	534.022	640.429	326.187
	850	302.734	387.629	430.392	540.801	299.875
	900	209.284	285.725	324.546	412.024	482.943
	950	129.706	180.883	218.362	290.857	297.302
	1000	12.662	22.468	39.262	82.228	127.966
	1050	7.803	19.431	39.084	74.580	118.680
0.25	800	440.546	507.896	512.967	605.056	323.688
	850	296.377	384.416	413.747	498.469	275.473
	900	207.812	286.280	315.470	387.414	444.992
	950	130.087	183.492	207.720	264.150	274.523
	1000	13.511	22.430	39.294	81.140	127.221
	1050	8.300	19.615	38.931	73.894	118.375

TABLE II.A-25: Ti-6Al-7Sn-4Zr-0.2Si Flow Stress Data
Flow Stress in MPA

(Not Corrected for Deformation Heating)

Strain	Temperature (°C)	Strain Rate (s^{-1}) 10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}
0.30	800	431.419	500.845	492.515	559.311	310.954
	850	288.644	377.140	397.161	450.975	235.729
	900	202.897	284.514	306.539	365.760	398.621
	950	128.440	184.544	198.866	245.453	255.851
	1000	13.708	22.668	39.255	78.824	124.907
	1050	8.060	19.533	38.647	72.995	117.079
0.35.	800	418.440	492.452	472.558	504.002	216.822
	850	278.741	368.924	383.033	413.064	137.814
	900	196.662	282.671	299.255	342.300	353.831
	950	126.072	184.830	192.807	227.830	239.738
	1000	13.921	23.016	38.950	76.866	123.245
	1050	8.251	19.490	37.785	72.812	115.815
0.40	800	404.266	481.054	451.867	439.127	115.340
	850	267.904	359.648	370.588	387.493	132.863
	900	190.977	277.710	290.687	318.444	303.413
	950	123.440	183.410	187.206	213.831	227.391
	1000	14.623	23.143	38.439	75.271	121.582
	1050	8.061	19.433	38.323	72.286	114.787
0.45	800	390.190	471.377	434.476	417.555	116.202
	850	256.639	349.137	359.955	376.442	137.605
	900	183.710	273.847	284.222	296.205	260.572
	950	120.567	181.984	182.650	202.045	216.750
	1000	14.989	23.375	38.070	74.533	119.316
	1050	8.279	19.223	38.044	72.148	113.054
0.50	800	376.230	460.951	424.297	428.096	139.753
	850	245.864	338.644	352.836	377.259	132.711
	900	177.119	270.707	279.129	279.652	233.060
	950	117.343	180.274	179.461	192.235	192.371
	1000	15.906	24.159	37.888	72.948	112.936
	1050	8.154	19.147	38.052	71.996	107.841

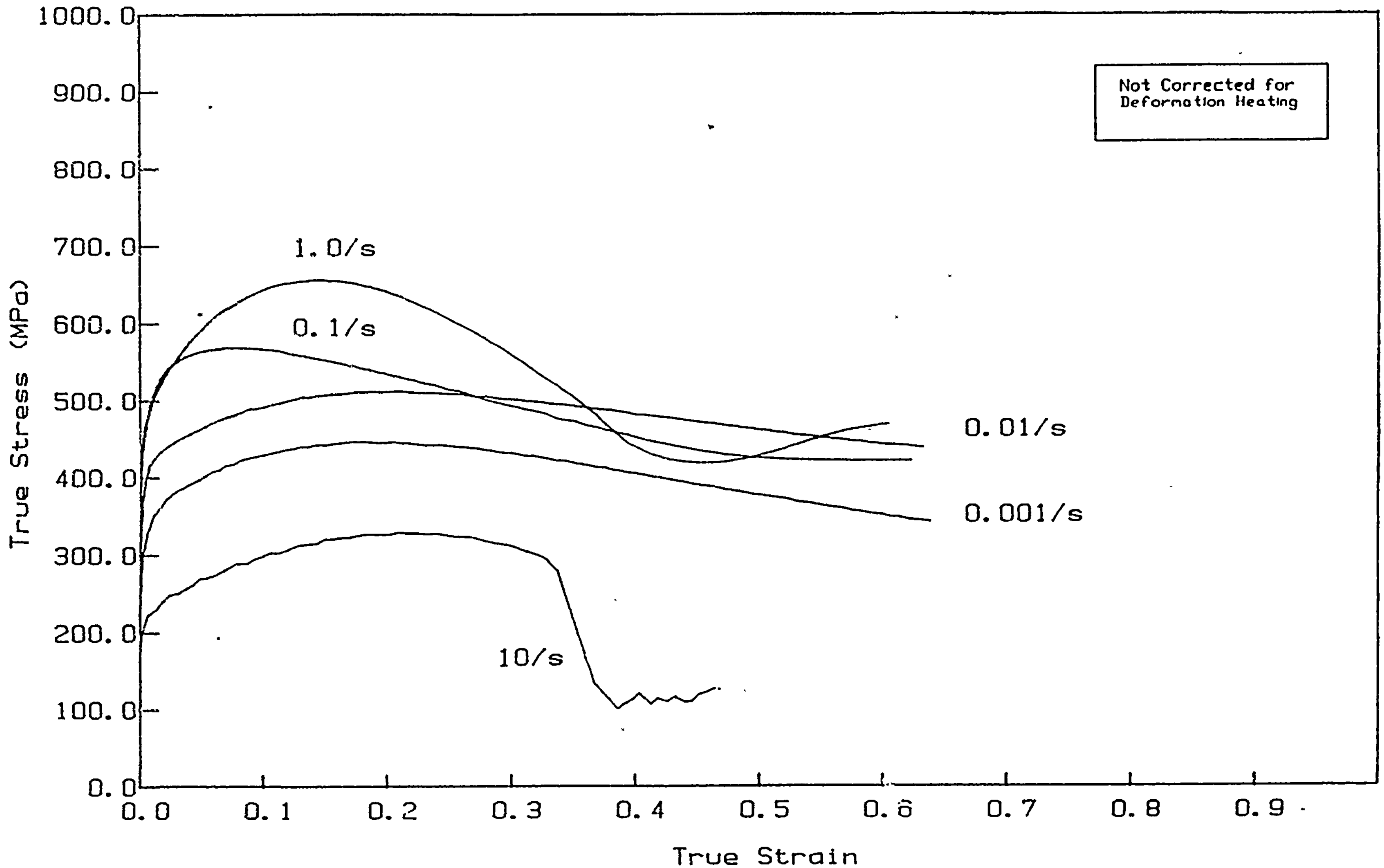


Figure II.A-35. Ti-6Al-7Sn-4Zr-0.2Si Tested at 800°C.

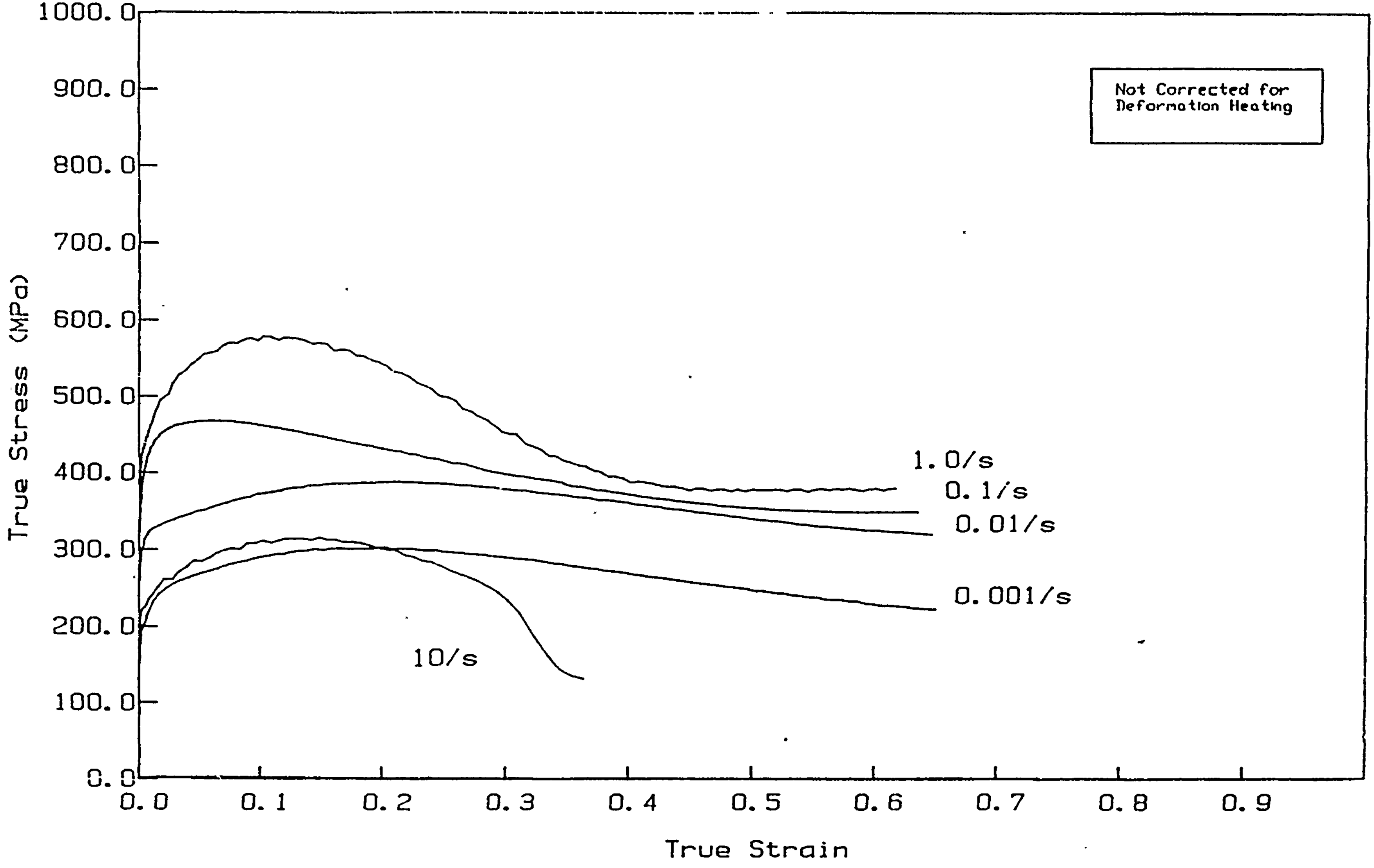


Figure II.A-36. Ti-6Al-7Sn-4Zr-0.2Si Tested at 850°C.

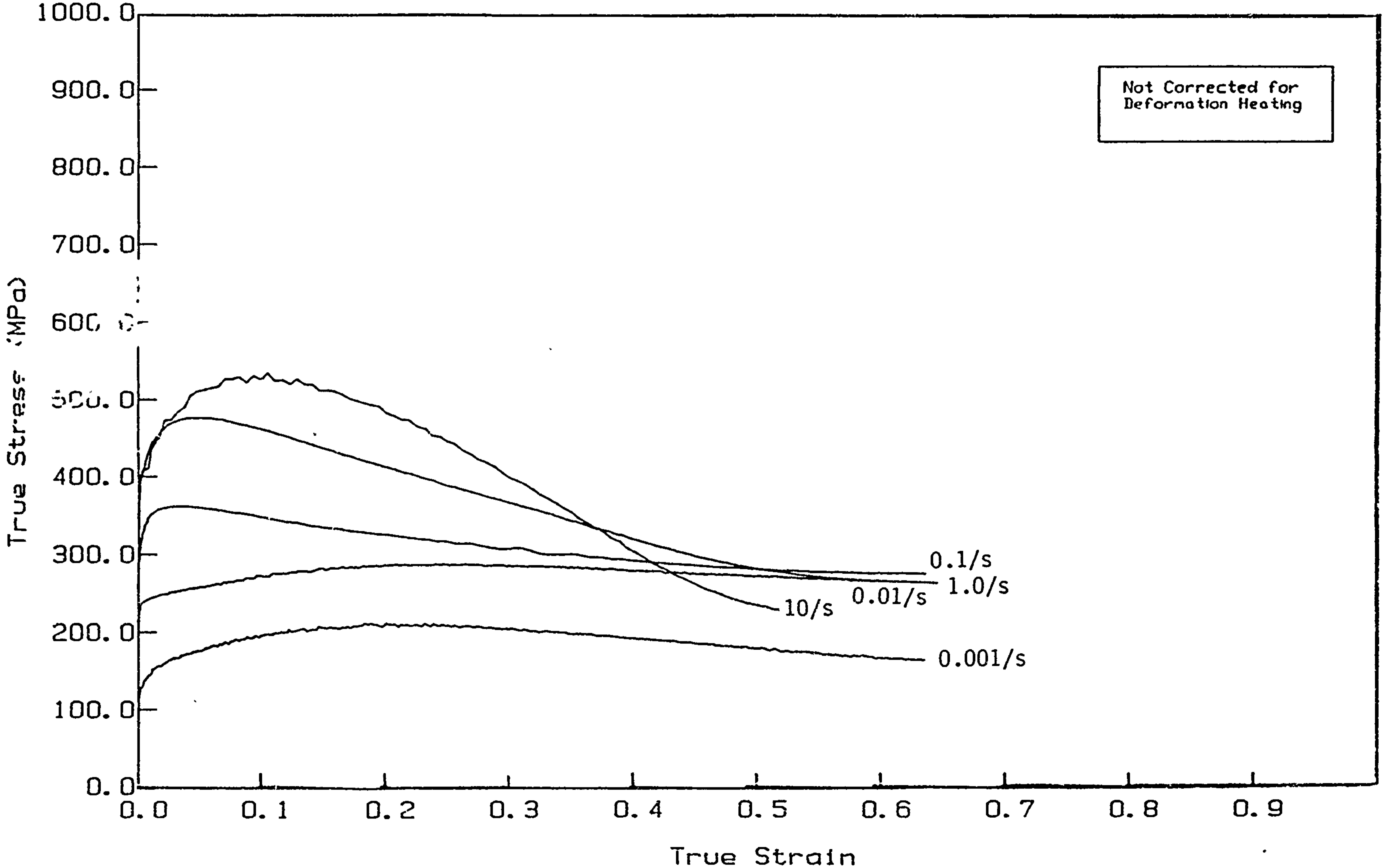


Figure II.A-37. Ti-6Al-7Sn-4Zr-0.2Si Tested at 900°C.

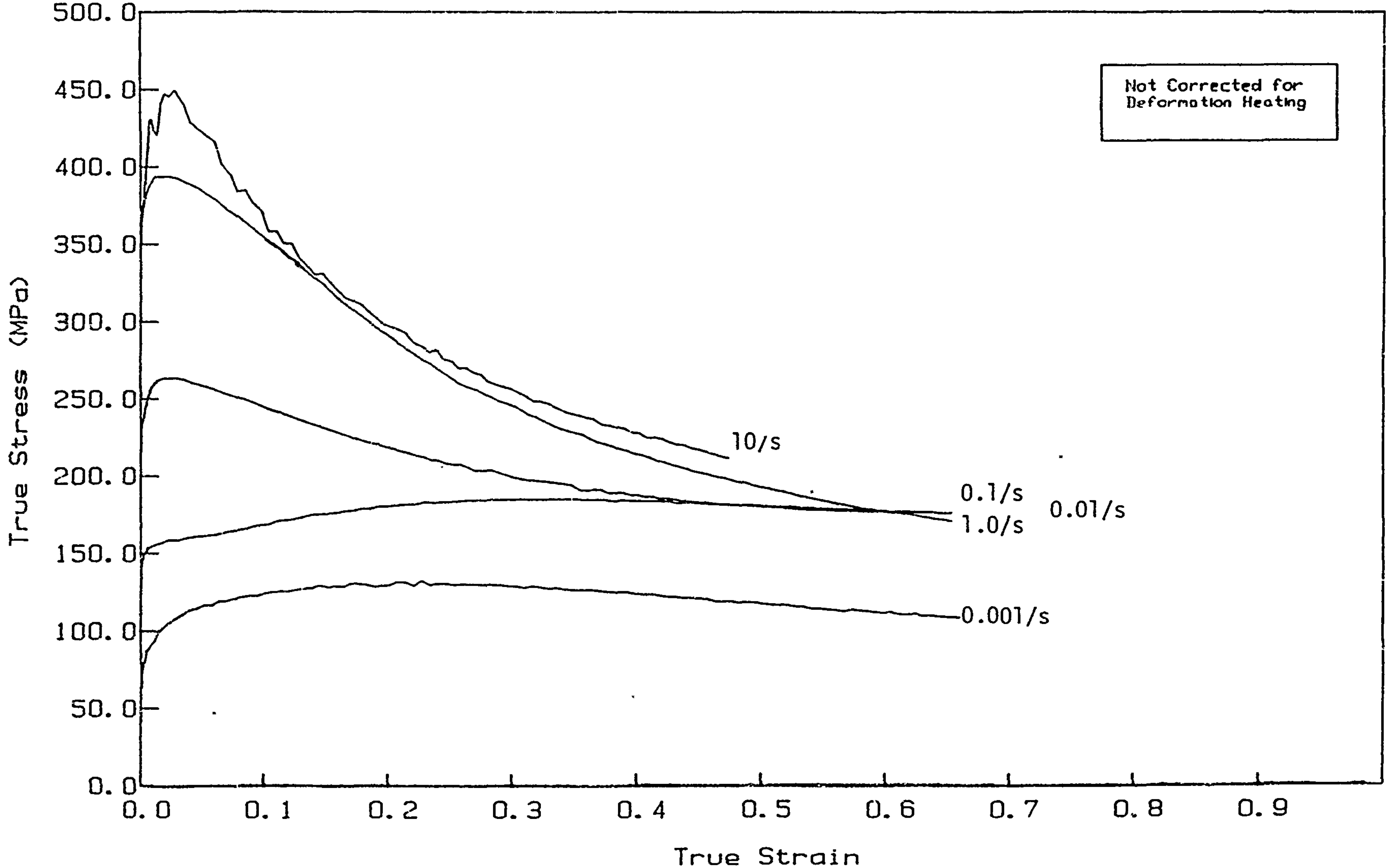


Figure II.A-38. Ti-6Al-7Sn-4Zr-0.2Si Tested at 950°C.

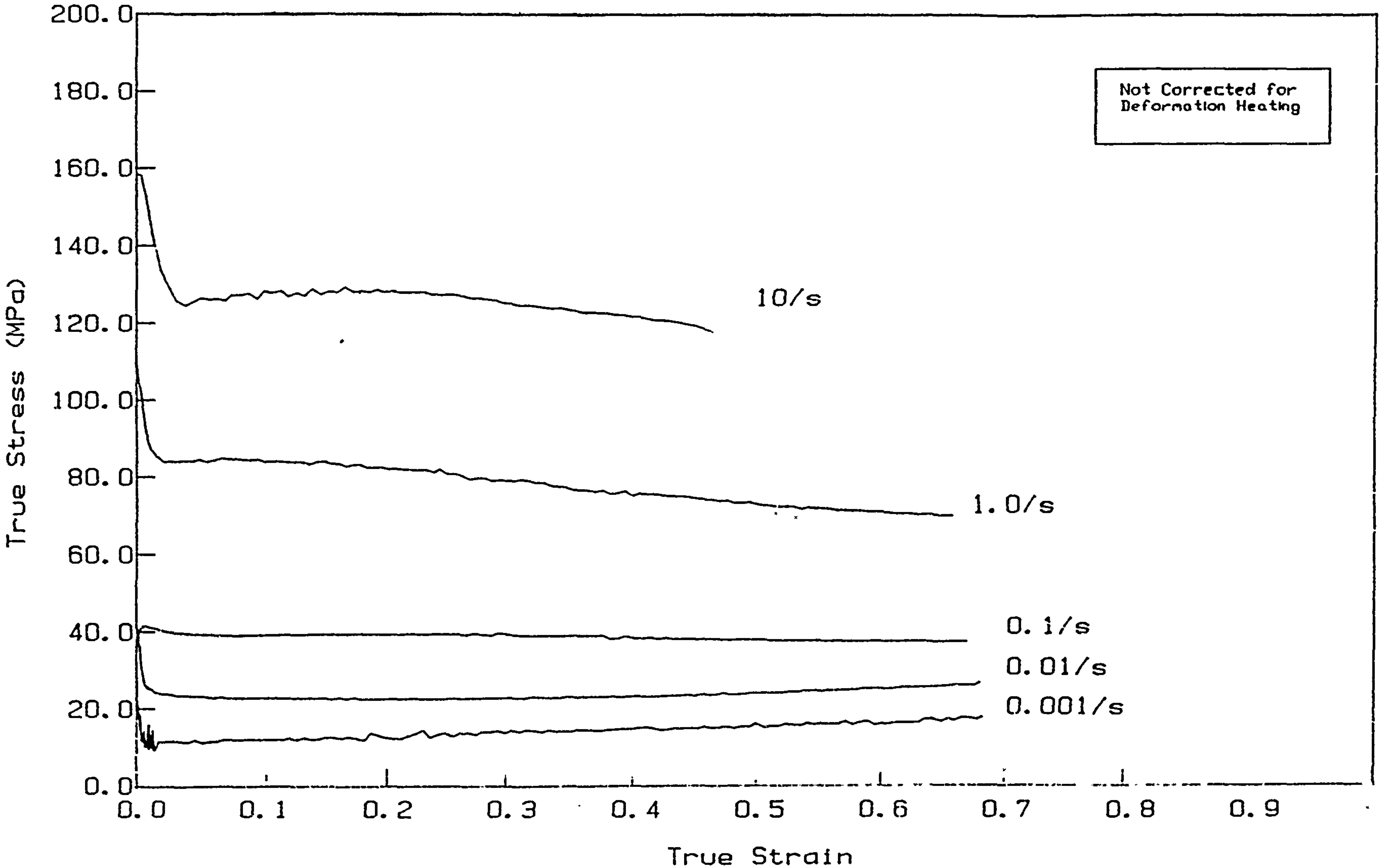


Figure II.A-39. Ti-6Al-7Sn-4Zr-0.2Si Tested at 1000°C.

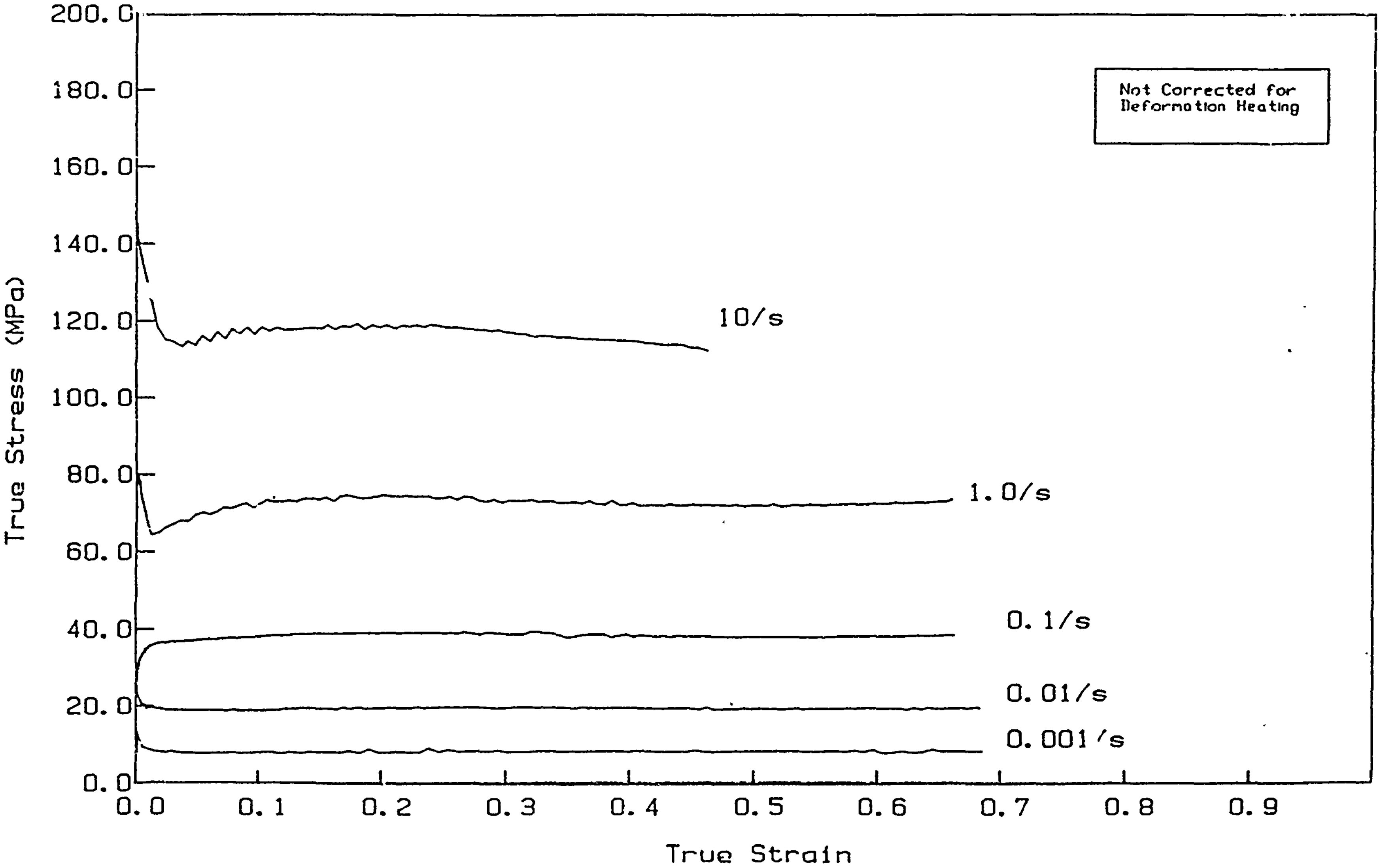


Figure II.A-40. Ti-6Al-7Sn-4Zr-0.2Si Tested at 1050°C.

TABLE II.A-26: Rene-88 (W2) Test Matrix

Temperature (°C)	Log10 (Strain Rate) -3.5	-3.0	-2.5	-2.0	-1.5	-1	-0.5	0.0
1010			N4	N5	N6	N7	N8	
1024			N12	N13	N14	N15	N16	
1038			N20	N21	N22	N23	N24	
1052		N27	N28	N29	N30	N31	N32	
1066		N35	N36	N37	N38	N39		
1079	N42	N43	N44	N45	N46	N47		

Note: This matrix shows the tests that have been completed so far. The remaining locations in the matrix will be completed later.

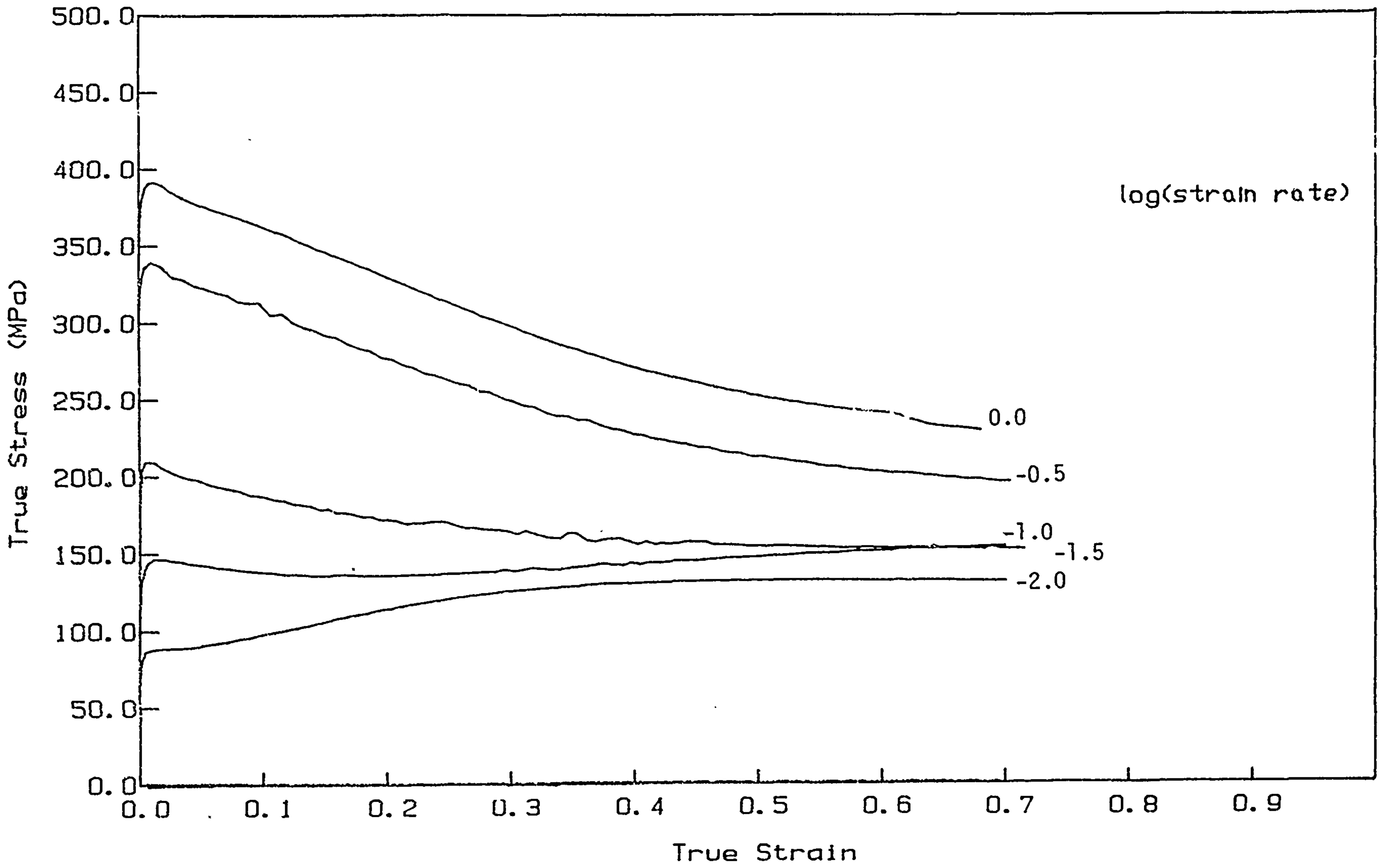


Figure.II.A-41. Rene-88 (W2) Tested at 1010°C.

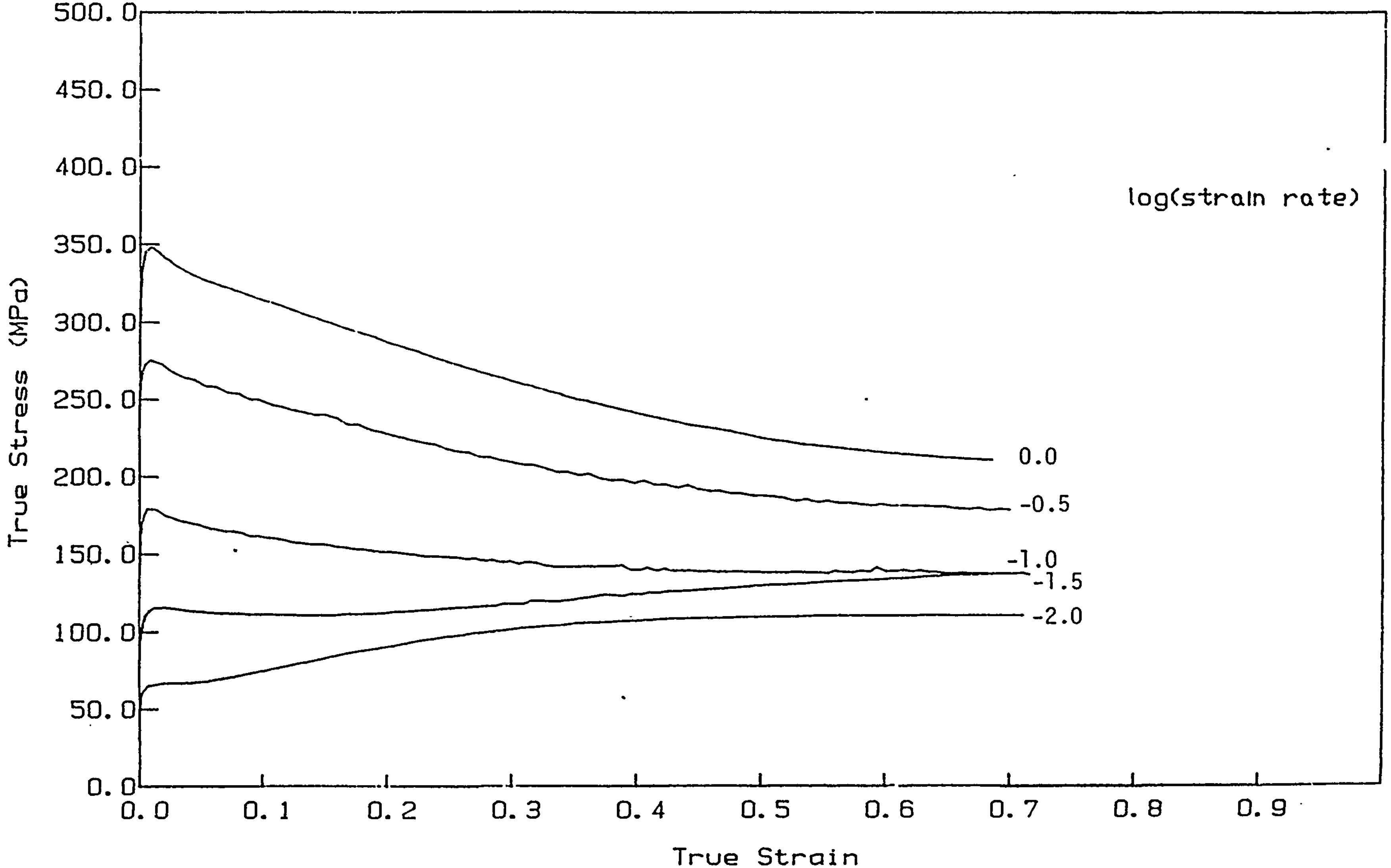


Figure II.A-42. Rene-88 (W2) Tested at 1024°C.

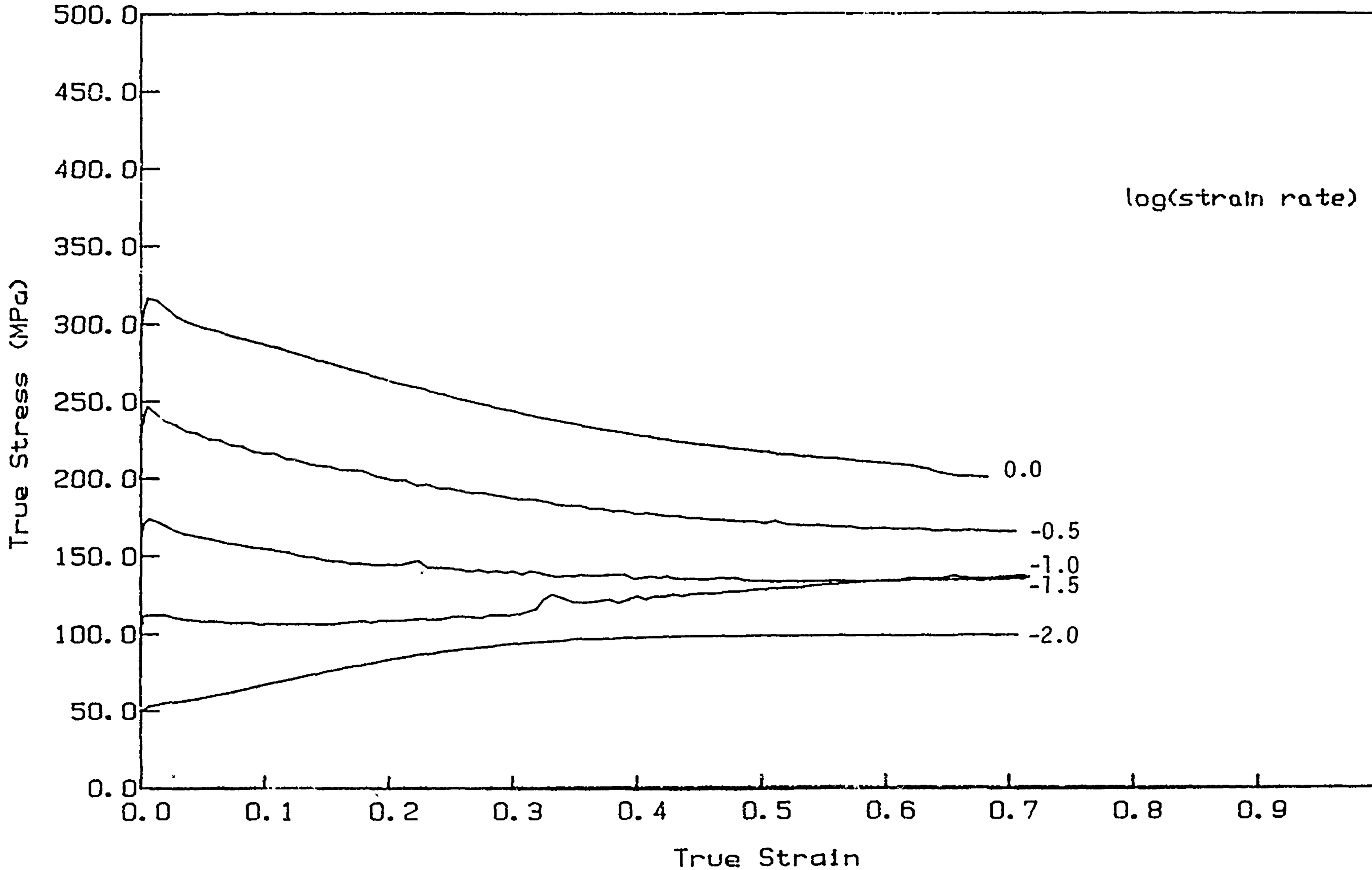


Figure II.A-43. Rene-88 (W2) Tested at 1038°C.

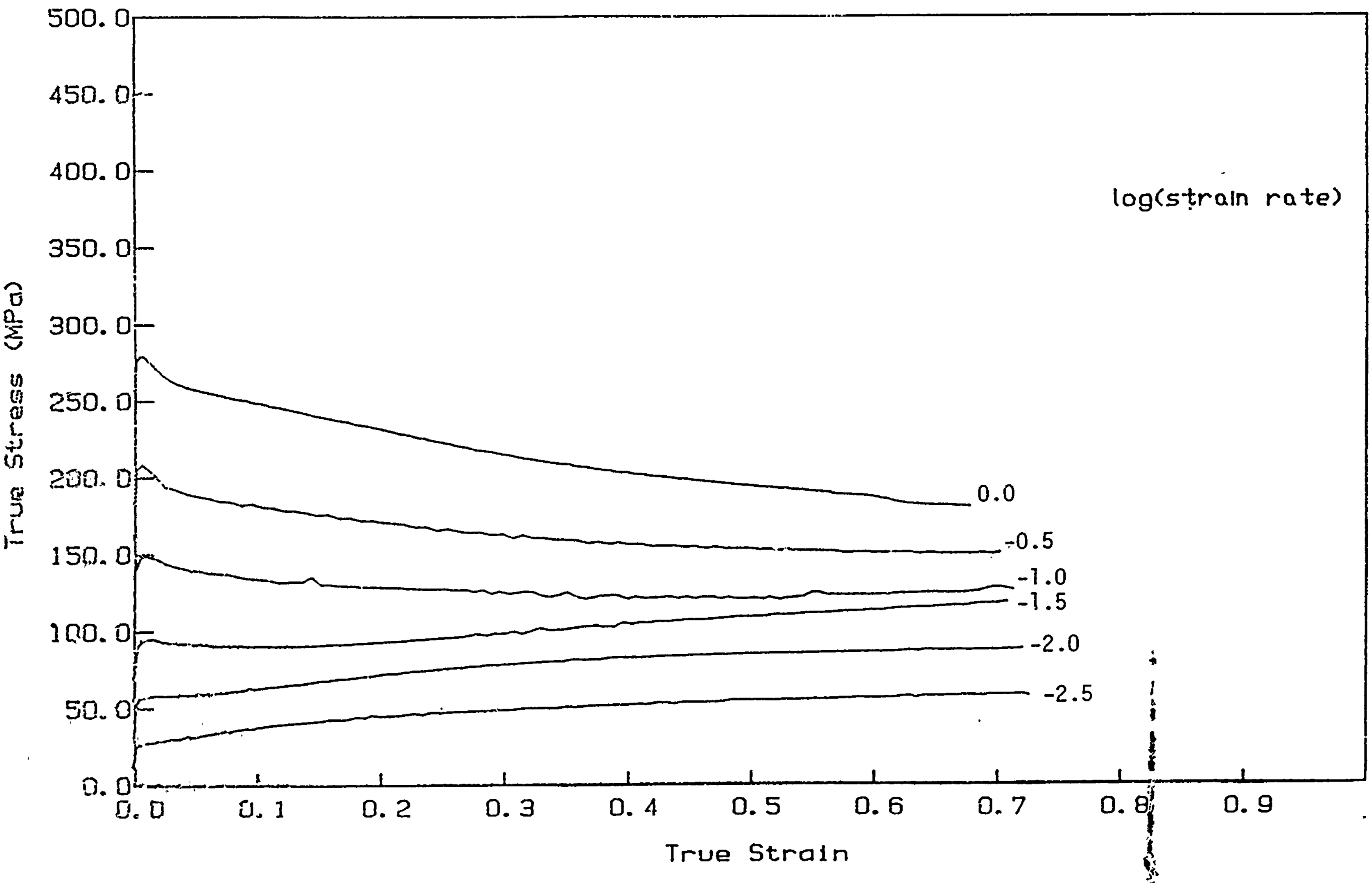


Figure II.A-44. Rene-88 (W2) Tested at 1052°C.

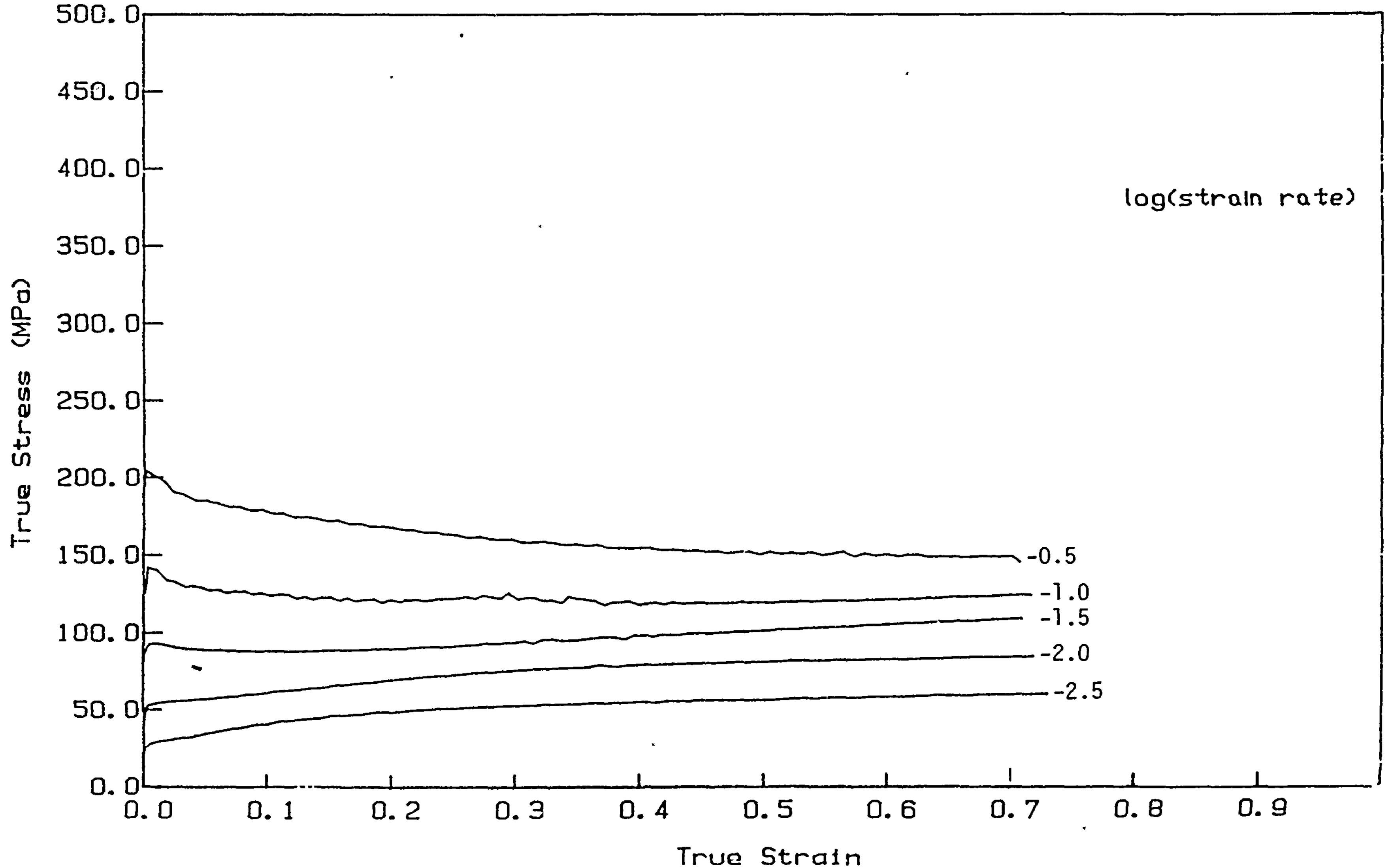


Figure II.A-45. Rene-88 (W2) Tested at 1066°C.

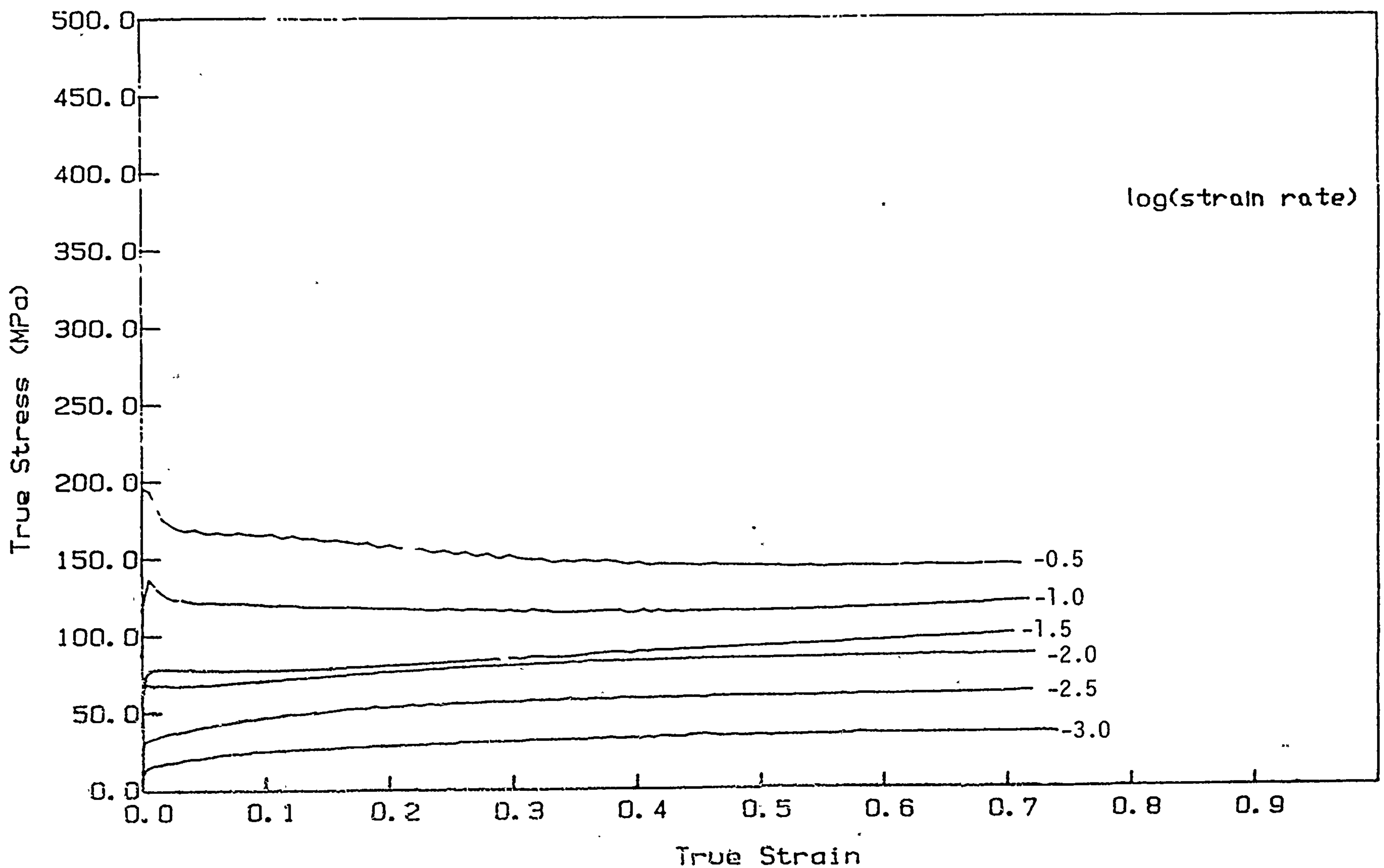


Figure II.A-46. Rene-88 (W2) Tested at 1079°.

II.B. LUBRICATION DATA BASE FOR THE EXTRUSION AND FORGING OF NICKEL-BASED ALLOYS - P. M. French/J. O. Brown

Review

The extrusion and forging records of the WRDC High Temperature Materials Development Laboratory were reviewed for lubrication data over the period from 1970 to the present time. Although there have been numerous extrusions of these materials, relatively few have been forged. A summary of extrusion data in a chronological form is given in Table II.B-1. The data is for solid billets and the extrusion of powder compacts. Data on the compaction of Ni-based powder material has not been included. Most of the data shown are for materials extruded over the last 2 years. With a few exceptions, most of the information from the earlier work appears to be very similar to the more current data. It should also be remembered that minimal in-house characterization has been undertaken in the past on the worked material, making it difficult to do a detailed analysis. Observations have usually been of the type, "good," "bad," "broke-up," etc., without giving further details. Obviously there is a need to obtain more characterization information in the future, both in-house and from the supplier. A typical extrusion data sheet is shown in Attachment II.B-1.

The extrusion data in Table II.B-1 are presented in chronological order. For reasons outlined above, no attempt has been made to group the data for particular alloys. However, materials of similar composition are frequently extruded as a group so some comparison can be made; e.g., nos. 9412-9416. Billet temperatures for extrusion are normally in the 1830-2275°F range, although a few have been undertaken outside these boundaries. These temperatures are used to determine which billet lubricant to use. (See Table II.B-1.) The temperatures are normally selected by the customer.

In this same time period, only four nickel alloys were forged (January 1980). The materials were melted buttons having the compositions, Ni-50%Mo, Ni-40%Mo, Ni-30%Mo and Ni-10%Mo, respectively. The lubricant in each case was the Corning Glass 0010. Attachment II.B-2 is a copy of the data sheet for these forgings.

TABLE II.B-1: Extrusion Data for Nickel-Based Alloys(1)

Date	Number	Lubricants	Reduction Ratio	Speed in/sec.	Temp. (^{o}F)	Composition	Results
1-87	9919	0010	9.7:1	0.78	2100	Ni-11.87Al-1.77Hf-.05B	Nose and tail broke off
1-87	9917	0010	12:3:1	-	2050	Ni-7.44Al-4.42Si-1.8Hf-.05B	Nose broke off.
1-87	9915	0010	11:9:1	0.47	2000	Ni-8.21Al-1.37Si-.05B-.5Ti	Broken
1-87	9914	0010	12:3:1	0.89	1900	Ni-8.0Al-4.8Si-1.53Hf-.05B-.103C	Good
1-87	9913	0010	12:3:1	0.96	1900	Ni-5.3Al-7.2Si-.05C-.5Ti	Good
1-87	9912	0010	12:3:1	0.79	1900	Ni-5.26Al-7.39Si-.05B	Good
1-87	9911	0010	12:3:1	0.89	1900	Ni-9.75Al-2.74Si-.05B	Good
12-86	9910	0010	6.6:1	1.07	2000	Ni-11.3Al-.11B-10.9Fe	Good
12-86	9909	0010	7.2:1	1.05	2000	Ni-8Co-13Cr-3.5Mo-3.5W-3.5Al-2.5Ti 3.5Nb-.02B-.03C-.03Zr	Good

(1)Extrusion of Powder Compacts

TABLE II.B-1: Extrusion Data for Nickel-Based Alloys[(1)]-(Continued)

Date	Number	Lubricants	Reduction Ratio	Speed in/sec.	Temp. (°F)	Composition	Results
12-86	9899[(1)]	0010	6.5:1	0.93	1900	Ni-18Co-15Cr-5Mo-5W-2.5Al-3Ti 3Nb-.01B-.08C-.05Zr	Good
9-86	9846	7052	4.6:1	3.8	2260	Ni-9Cr-6.8Al-1Mo-9.4W-3Ta-.15Hf-.1Y	Good
9-86	9847	7052	4.5:1	3.4	2260	Ni-9Cr-6.8Al-1Mo-9.4W-3Ta-.15Hf-.1Y	Good
9-86	9848	7052	4.5:1	3.5	2260	Ni-9Cr-6.8Al-1Mo-9.4W-3Ta-.15Hf-.1Y	Good
7-86	9804	7052	16.3:1	1.0	2280	Ni-8.9Cr-6.8Al-9.7W-3.0Ta-1.0Mo	Good
7-86	9803	7052	16.4:1	1.0	2280	Ni-8.9Cr-6.8Al-9.7W-3.0Ta-1.0Mo	Good
7-86	9802	7052	16.6:1	1.0	2275	Ni-8.3Cr-6.6Al-9.7W-3.0Ta-2.0Mo .10C-.01B-.05Zr	Good
7-86	9801	7052	15.8:1	1.0	2245	Ni-8.9Cr-6.8Al-9.7W-3.0Ta-1.0Mo	Good
6-86	9800	7052	15.8:1	1.0	2245	Ni-8.9Cr-6.8Al-9.7W-3.0Ta-1.0Mo	Good
6-86	9799	7052	16.6:1	1.0	2245	Ni-8.3Cr-6.6Al-9.7W-3.0Ta-2.0Mo .10C-.01B-.05C	Good
6-86	9797	0010	18.7:1	-	2100	Ni-26Al	Nose and tail broke off
6-86	9796	0010	20:1	-	2100	Ni-25Al	Good
6-86	9795	0010	9.2:1	-	1830	Ni-Al	Good
6-86	9794	0010	9.3:1	-	1830	Ni-Al	Good
6-86	9793[(1)]	0010	7.3:1	-	2000	Ni-17.0Co-15.0Cr-5.0Mo-2.5Al-4.7Ti-1.6Nb-.03B-.06C-.06Zr	Good
6-86	9768	0010	12.3:1	2.0	2000	Ni-5.30Al-3.94Si-.05B-5.23Fe-1.67Hf	Good

TABLE II.B-1: Extrusion Data for Nickel-Based Alloys[(1)] (Continued)

Date	Number	Lubricants	Reduction Ratio	Speed in/sec.	Temp. (°F)	Composition	Results
6-86	9762	0010	12.1:1	2	1900	Ni-9.75Al-2.74Si-.05B	Good
4-86	9757[(1)]	0010	6.2:1	2	2050	Ni-18.1Mo-6.8Al-5.1Co-2.7Cr-2.6V-.02B	
4-86	9753[(1)]	0010	6.9:1	2	2000	Ni-10.1Fe-8.3Al-6.0Nb-2.9Hf-.10B	Good
4-86	9722	0010	8.0:1	2	2100	Ni-7.5Al-1.78Si	Fair
4-86	9719	0010	9:1	1.9	2100	Ni-7.5Al-1.78Si	Fair
10-85	9638[(1)]	0010	7.2:1	2	1900	Ni-13Co-16Cr-5.5Mo-2.5W-2.1Al-3.7Ti-.7Cb-.2Hf-.015B-.03C-.03Zr	Good
10-85	9637[(1)]	0010	7.1:1	2	1900	Ni-13Co-16Cr-5.5Mo-2.5W-2.1Al-3.7Ti-.7Cb-2Hf-.015B-.03C-.03Zr	Good
10-85	9636[(1)]	0010	7.2:1	2	1900	Ni-13Co-16Cr-4Mo-4W-2.1Al-3.7Ti-.7Cb-.03B-.03C-.03Zr	Good
10-85	9635[(1)]	0010	7.2:1	2	2000	Ni-17Co-15Cr-5Mo-2.[illegible]Al-6.2Ti-.03B-.06C-.06Zr	Good
10-85	9634[(1)]	0010	7.2:1	2.2	2000	Ni-17Co-15Cr-5Mo-3Al-4.8Ti-.03B-.06C-.06Zr	
10-85	9633[(1)]	0010	7.2:1	2.2	2000	Ni-17Co-15Cr-5Mo-4Al-3.5Ti-.03B-.06C-.06Zr	Good
10-85	9632[(1)]	0010	7.2:1	2.1	2000	Ni-8Co-10Cr-5Mo-3.5Al-2.5Ti-3.5Cb-.2Hf-.015B-.03C-.03Zr	Good
10-85	9631[(1)]	0010	7.2:1	2.2	2000	Ni-16Co-15Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Cb-.2Hf-.015B-.03C-.03Zr	Good
10-85	9630[(1)]	0010	7.2:1	2.1	2000	Ni-12Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Cb-.02Hf-.015B-.03C-.03Zr	Good

TABLE II.B-1: Extrusion Data for Nickel-Based Alloys[1] -(Continued)

Date	Number	Lubricants	Reduction Ratio	Speed in/sec.	Temp. (°F)	Composition	Results
9-85	9550	7052	17.1	3.3	2175	Ni-8.9Cr-6.7Al-9.4W-3Ta-1Mo-.15H-.02Y	?
9-85	9549	7052	17.1	3.0	2210	Ni-9.4W-8.9Cr-6.7Al-3Ta-.15Hf-.02Y	Good
9-85	9548	7052	17.1	2.9	2175	Ni-9.4W-9Cr-6.7Al-3Ta-1Mo-.15Hf-.02Y	?
8-85	9537	0010	9.3	3.6	2175	Ni-10.64Co-8.04Al-6.45Hf-.92V-.51Si-.05B	?
8-85	9536	0010	9.2	2.8	2175	Ni-10.64Co-8.04Al-6.45Hf-.92V-.51Si-.05B	Bad
8-85	9535	0010	9.2	4.3	2175	Ni-10.52Co-6.98Al-6.37Hf-.91V-.50Si-.05B	Bas X-Mas Tree
8-85	9534	0010	9.2	2.5	2175	Ni-10Co-9Al-6Hf-1V-.50Si-.05B	Broke Up
8-85	9533	0010	9.2	4.1	1830	Ni-31.5Al	Good

TABLE II.B-1: Extrusion Data for Nickel-Based Alloys[1] -(Continued)

Date	Number	Lubricants	Reduction Ratio	Speed in/sec.	Temp. (°F)	Composition	Results
7-85	9500	7052	8.9	3.0	2175	Ni-10.64Co-8.04Al-6.4Hf-.92V-.51Si-.05B	Pieces
7-85	9499	7052	8.9	3.0	2175	Ni-10.64Co-8.04Al-6.4Hf-.92V-.51Si-.05B	Pieces
7-85	9498	7052	8.9	3.0	2175	Ni-10.52Co-6.9Al-6.37Hf-.91V-.50Si-.05B	Bad. Broke up.
7-85	9497	7052	9.1	3.0	2175	Ni-10Co-9Al-6Hf-1V-.50Si-.05B	Bad.
7-85	9511	7052	15.1	3.6	2265	Ni-9.4W-8.7Cr-6.5Al-3Ta-1Hf-1Mo-.02Zr-.01Y	Good.
7-85	9510	0010	12.5	3.3	2100	Ni-12.8Al-12B	Good.
7-85	9509	0010	12.5	3.3	2100	Ni-12.5Al-1Mo-.2Ti-.19B	Good.
7-85	9508	0010	12.5	4.6	2100	Ni-12.8Al-1Mo-.12B	Good.
7-85	9528	0010	7.1	4.1	2000	Ni-9.27Al-3.2Hf-6.7Nb-1B	Good. Plug Separation.
7-85	9527	0010	7.1	4.1	2000	Ni-9.42Al-8.5Nb-0.1B	Good. Some Plug Separation.
7-85	9526	0010	7.1	4.1	2000	Ni-11.98Al-1.76Zr-0.1B	Good.
7-85	9525	0010	7.1	3.8	2000	Ni-11.78Al-3.9Hf-0.1B	Excellent.
7-85	9524	0010	7.1	3.8	2000	Ni-12.7Al-0.1B	Good. Plug Separation.

TABLE II.B-1: Extrusion Data for Nickel-Based Alloys[1] - (Continued)

Date	Number	Lubricants	Reduction Ratio	Speed in/sec.	Temp. (^{o}F)	Composition	Results
3-85	9416	7052	15.0	3.8	2265	Ni-6.5Al-6Cr-6Ta-6W-4Mo-.15Hf-.02Y	Good.
3-85	9415	7052	15.0	3.3	2265	Ni-9.7W-8.9Cr-6.1Al-3Ta-1.5Hf-1Mo-.02Y	Good.
3-85	9414	7052	15.0	3.3	2265	Ni-9.7W-8.9Cr-6.7Al-3Ta-1Mo-.5Hf-.2Zr-.02Y	Good.
3-85	9413	7052	15.0	3.3	2265	Ni-9.7W-8.9Cr-6.7Al-3Ta-1Mo-.15Hf-.02Y-.015B	Good.
3-85	9412	7052	15.0	3.3	2265	Ni-9.7Al-8.9Cr-6.7Al-3Ta-1Mo-.15Hf-.02Y-.012B	Good.
1-85	9364	0010	9.0	0.8	2000	Ni-23.5Al-.25B	Good.
1-85	9363	0010	9.0	4.1	1830	Ni-50.0Ti	Good.
1-85	9362	0010	9.0	3.0	1830	Ni-43Al	Good.
1-85	9361	0010	9.0	3.0	1830	Ni-43Al-.25B	Good.
1-85	9359	0010	9.0	3.0	1830	Ni-50Al-.25B	Good.
1-85	9358	0010	9.0	3.3	1830	Ni-50Al	Good.
1-85	9357	0010	9.0	2.8	1830	Ni-51.5Al-.25B	Good.
1-85	9356	0010	9.0	2.8	1830	Ni-54Al-.25B	Good.

TABLE II.B-1: Extrusion Data for Nickel-Based Alloys[1] -(Continued)

Date	Number	Lubricants	Reduction Ratio	Speed in/sec.	Temp. (°F)	Composition	Results
4-85	9357	0010	9:1	1.1	1830	Ni-51.5Al-0.25B	Good.
4-85	9360	0010	8.4:1	1.1	1830	Ni-48.5Al-0.25B	Good.
10-84	9266	7052	16.6:1	1.4	2270	Ni-8.9Cr-6.7Al-9.4W-1Mo-3Ta-0.2C-0.20Y	Good.
10-84	9265	7052	16.6:1	1.1	2270	Ni-8.9Cr-6.7Al-9.4W-1Mo-3Ta-0.2C-0.20Y	Good/Split in Bar 12" From Nose.
8-83	8798[1]	7052	16.3:1	1.2	2250	Ni-10W-6Al-1Mo	Good.
8-83	8797	7052	10.2:1	1.3	2175	Ni-10Co-10W-8.3Cr-5.5Al-3Ta-1.5Hf-1Ti-0.7Mo-0.15C-0.05B	Good. (P&W/Army/DARPA Program).
6-71	4192	0010	16:1	1.9	2200	Ni-16Cr-3.5Al-2ThO_2	Good.
8-71	4149	0010	8.7:1	2.6	2100	Ni-9Cr-9Co (Universal Cyclops)	Good.
8-71	4141	0010	8.9:1	2.6	2100	Ni-9Cr-9Co	Good (Cracking in Bar).
2-71	4101	0010	19.8:1	1.1	2200	Ni-16Cr-5Al-0.24ThO_2	Good.
2-71	4100	0010	19.8:1	1.1	2200	Ni-20Cr-4Mn-2ThO_2	Good.

AIR FORCE MATERIALS LABORATORY

Experimental Metals Processing Laboratory

WRIGHT-PATTERSON AIR FORCE BASE, OHIO

Attachment II.B-1

EXTRUSION DATA SHEET

SERIAL NO. 9919

DATE Jan 12, 1987 TIME

PURPOSE OF TEST Pratt & Whitney/Florida (Ron Simon) (MY)

BILLET – Composition Ni-11.87Al-1.77HF-.05B Identity SSXC-16-1 Weight 11.9

Diameter 2.870 Length 7" End Shape 1/2" 45^{o}

BILLET ACCESSORIES – Nose Block Follow Block 2-7/8" 3" carbon + 2 ea. Glass

Jacket Other

CONTAINER – Size (I.D.) 3.072 Temp. 500 °F Mat'l

Condition 1135

DIE – Identity Ratio 10.24:1 Type 60^{o} conical Mat'l Size .960

Hardness Facing Zr02 No. Time Used New Temp. 500 °F

Condition Before After

BILLET HEATING – Type Preheat Time Temp. °F

Type Final Heat Harrop Time 2 hrs. + 30 Mins. Temp. 2100 °F

--ICANT – Billet Precoat Mat'l Qty. How Applied

Billet Final Mat'l 0010 Qty. 0.030 How and When Applied Brush

Container Fiske 604

Die Polygraph

ACCUMULATOR – Start (psi) 3050 Finish (psi)

BILLET TRANSFER (Sec) – Fce to Cont. Cont. to Pres. Total

HIGH PRESSURE ADMISSION – L S Setting Manual Automatic

LOAD (Tons) – Maximum 545-147.1 ksi Minimum Bottom

RAM SPEED – Valve Setting (Turns) 2 Maximum (ips) Minimum (ips) 0.78 ips

EXTRUDED Bar – Length 54 1/2" Desc. Nose+Tail Broke off Yield Wt.

REFERENCES.– Photo No. X-Ray No. Spec's

COMMENTS – Air cooled

N	C	T	NB	SI	ER
	0.985		0	9"	9.73:1

AFML FORM 23 MAY 64

AFLC—WPAFB—MAR 68 2M

1.001
0.301 = 000 Between Die
153

WWD-2306-P106

FORGING DATA SHEET

SERIAL NO. 5785 TO 5788

DATE Jan 23, 1980 MAX. YIELD — BASIC FORGING ______ TIME ______

PURPOSE OF TEST AFML/LLM Dan Miracle, To attain greater degree of chemical homogeneity ~ 50% red.

BILLET: COMPOSITION Note Below IDENITY 877, 878, 879, 880,

BILLET DIMENSIONS: ~~O.D.~~ OR THICKNESS 0.663, 0.672, 0.485 + 0.524 LENGTH ______ SHAPE ______

DIES: SIZE 3 3/4" x 3 3/4" TEMP. 1650 °F. MATERIAL 713°C

STOP BLOCKS: SIZE — TEMP. — °F. FURNACE — HARDNESS — COATING — MATERIAL ______

BILLET HEATING: TEMP. 2190 °F. TIME 30 MINS. FURNACE Harrop

REHEAT TEMP. ______ °F. TIME ______ MINS. FURNACE ______

VALVE SETTING 1 ACCUMULATOR 3050 VISICORDER CHANNEL ______ VOLTAGE ______ SENSITIVITY No

FORGE NO.	HEIGHT BEFORE SNDBAST	TEMPERATURE DIE	TEMPERATURE SPEC	ACTUAL REDUCT	LUBRICATION DIE	LUBRICATION SPEC	RAM SPEED	PEAK LOAD	FINAL DIMENSIONS O.D.	FINAL DIMENSIONS HEIGHT	FINAL DIMENSIONS I.D.	FILM THICKNESS INITIAL	FILM THICKNESS FINAL	FILL MAT. SIZE
877 5785		1650	2190	58.4%	None	.0010	1 Turn	No Read		0.275				0.330
878 5786			2190	58.9%	"	"		No Reading		0.276				0.330
879 5787			2190	60.4%	"	"				0.192				0.250
880 5788			2190	65.6%	"	"				0.140				0.250

#		
877	50Ni + 50Mo	Didn't use visicorder for pressure measurement
878	60Ni + 40Mo	
879	70Ni + 30Mo	
880	90Ni + 10Al	

II.B-10

Attachment II.B-2

Attachment II.B-3 is a listing of the suppliers of the various lubricants used. Two Corning Glass products have been utilized for billet lubrication; namely nos. 0010 and 7052. Product 0010 is a potash soda lead glass and has usually been used over the temperature range 1400-2100°F. Product 7052 on the other hand is a borosilicate glass and generally been used in the higher temperature range 2100-2500°F. We have recently been informed by Corning that they no longer supply product 0010 - possibly because of its lead content, although similar type glasses are available. At our request, Corning is going to provide us with a hazardous product use report, which we will review and circulate. The glass materials are supplied in powder form (-100 mesh). For our application, the glass powders are made into a slurry, in a vented hood, using water with carbopol to aid in powder suspension. An approximately 0.030-in. coating is allowed to dry at room temperature prior to loading the billet into the soaking furnace.

We have a Corning Glass Products catalog on file. This lists a lot of property and applications data, but unfortunately, no information on chemical composition. Presumably Corning regards the latter as proprietary information.

Conclusions

- Insufficient characterization data has been obtained in the past to permit an in-depth analysis.
- As a result of limited in-house characterization data, we cannot conclude that a particular lubricant is the primary reason for a good or bad extrusion.
- For a good extrusion, the combination of processing conditions selected is obviously satisfactory and that to a first approximation the lubricant utilized is acceptable.
- Conversely, if we have a bad extrusion, the combination of processing conditions was not ideal and to a first approximation, the lubricant selected may not have been the optimum one.
- Only two billet lubricants were apparaently used over the period reviewed, namely Corning Glass Products Nos. 0010 and 7052.

LUBRICANT SUPPLIERS

0010 (-100 Mesh) and 7052 (-100 Mesh)
Corning Glass Works
Houghton Park
Corning, NY 14830
(607) 974-7907
Marty Barrow

Polygraph
United Guardian, Inc.
P. O. Box 2500
Smithtown, NY 11787
(516) 273-0900
Bob Rubinger

DGF-123 and #5200
Miracle Power Products
1101 Belt Line St.
Cleveland, OH 44109
(216) 741-1388

Fiske-604
Fiske Brothers Refining Co.
P. O. Box 8038, Sta. A
Toledo, Ohio 43605
(419) 691-2491
Steve Pauli

Fel Pro(C-300)
Sealing Specialists
P. O. Box 9524
Pittsburgh, PA 15223
(412) 781-4300

Recommendations

- Lubricant 0010 contains lead and consequently its use should be discontinued until a detailed safety analysis has been undertaken on this product.

- The two glass products are received in fine powder form. Consequently, not only should these materials be handled in a vented hood but operators should also wear a face mask when working with these powders.

- An experiment should be undertaken to replace the 0010 lubricant with 7052, at least on an interim basis, for the extrusions in the temperature range, 1600-2000°F.

- A controlled extrusion experiment should be devised to define optimum lubricant use as related to overall processing conditions for the Bldg. 51 operations.

- There is obviously a need to obtain more detailed characterization data on the extruded and forged products. It is not sufficient just to report "good" or "bad" etc. This data should not only be obtained from in-house facilities but also from the "customer" for whom the work is being performed.

- A standard request for characterization data should be made to all customers.

- An attempt should be made to collect the following additional characterization data on all extrusion and forged materials:

  - Photograph the groups of extruded and forged billets to provide a visual record, particularly of any surface defects.

  - Request that the customer provide data in the areas of analytical chemistry, metallography, mechanical properties and NDT.

  - On a selected basis, undertake characterization of samples at WRDC in the following areas;

    Analytical Chemistry
    Metallography
    NDT

  - In the NDT area, radiography and ultrasonic testing should be undertaken on-site to check for internal defects. If there is any concern regarding the integrity of welded containers, these tests could be supplemented by either leak checking or dye-penetrant testing. Arrangements are being made to visit NDT facilities of the Systems Support Group on-site to review their capabilities.

II.C. LUBRICANT OPTIMIZATION USING Ti-6Al-4V RINGS - V. Jain

During plastic deformation, the lubricant at the material-die interface plays several important roles: (a) it influences the friction conditions at the interface and (b) it controls the heat transfer from the workpiece into the dies and therefore the temperature gradients within the deforming metal. The net effect is to influence the metal flow within the deformation zone and the press forces. In addition, lubricants affect such factors as workpiece surface quality, grain structure, mechanical properties, dimensional consistency, and load and energy requirements. Lubricants also provide effective separation between the workpiece and die and promote long die life.

Ring Test

The ring compression test has proven very useful and gained wide acceptance in predicting friction factor under various conditions including temperature, lubrication, strain rate, and strain. The test consists of compressing a flat, ring-shaped specimen to a known reduction between two flat dies. As the height is reduced, the ring expands outward radially. If friction at the interface is zero, both the inner and outer diameter expand as if the ring were a solid disk. With increasing friction, the increase in the inner diameter decreases. For any particular reduction in height, there is a critical value of friction factor m, whereby the inner diameter increases (from the original) if m is low, and decreases if m is large.

Master calibration curves, similar to those shown in Figure II.C-1 are used to determine friction factor and coefficient of friction from the dimensions of deformed and undeformed rings. The curves are available from Male and Cockroft's analysis for two ring geometries; i.e., 6:3:2 and 6:3:1 (OD:ID: thickness), or can be developed using ALPID analysis. In our case, the calibration curves were developed for a ring geometry of 6:3:1 using ALPID.

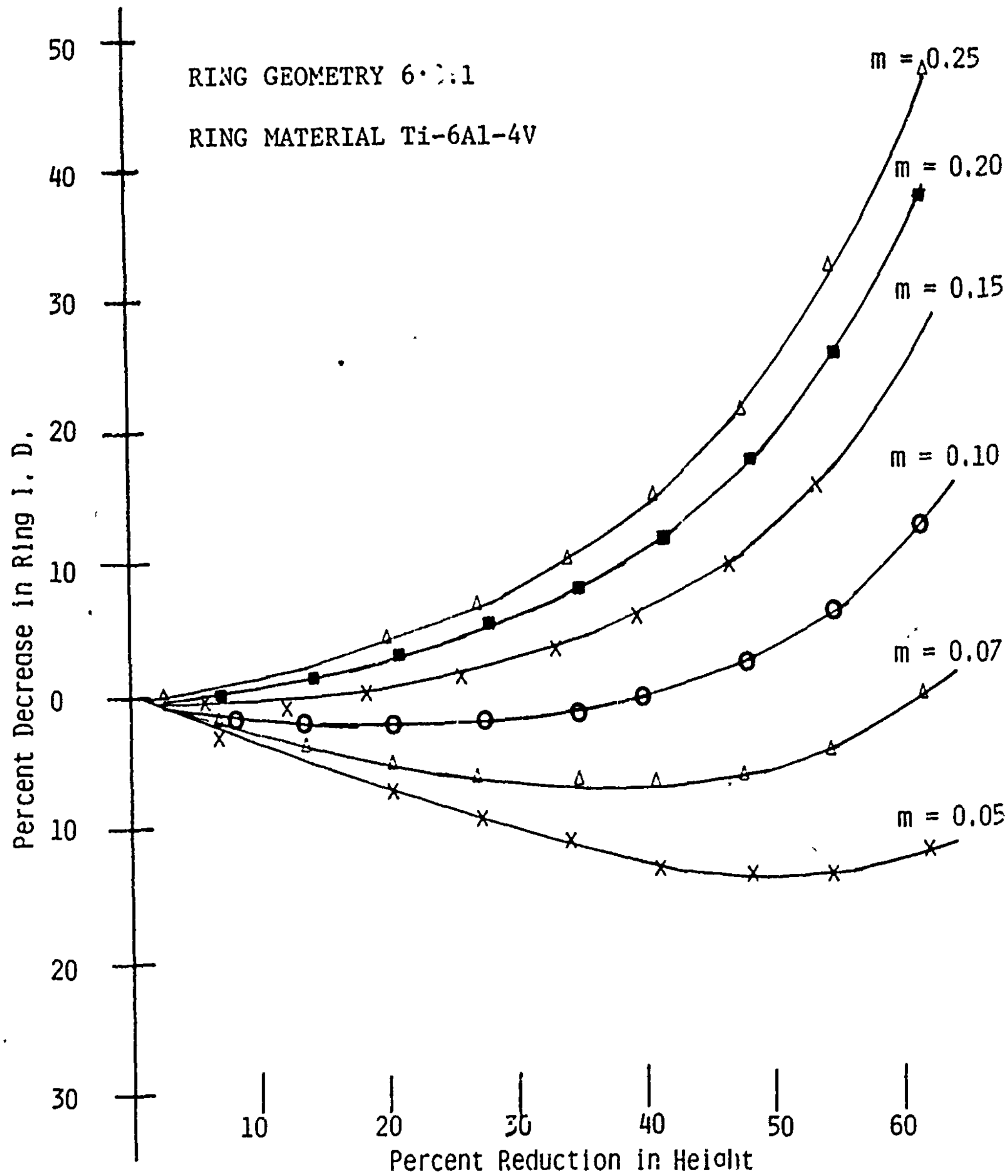


Figure II.C-1. Calibration Curves for Ring Compression Curves Developed by ALPID Simulation.

Experimental Procedure

Ring compression tests were performed for the measurement of friction factor between Ti-6Al-4V rings and IN-713C alloy dies. Ring specimens, OD = 1.75 in., ID = 0.875 in., thickness = 0.292 in. (6:3:1) were machined from Ti-6Al-4V rod. The rings were coated with various lubricants by A. O. Smith Company. The composition of the lubricants was proprietary and is not available. The rings were heated to 1650°F in a furnace and compressed isothermally to about 50 percent height reduction. After compression, the rings were quenched, cleaned by sandblasting, and dimensions were measured for computing the friction factor using the master calibration curve shown in Figure II.C-1. As mentioned before, these curves were generated by ALPID for a ring geometry of 6:3:1. Four ring tests were conducted to determine the friction factor for one lubricant, to obtain reliable data, and exclude the effect of surface modifications during testing. The results of various tests are given in Table II.C-1.

TABLE II.C-1: Values of Friction Factors (m) for Various Lubricants

Lubricant	Forging Numbers	m	Arithmetic Average of Surface Roughness in μ in.
191	6709-6712	0.083	-
192	6713-6716	0.075	120
194	6717-6720	0.0675	-
195	6721-6724	0.075	125
196	6725-6728	0.070	-
198	6729-6732	0.092	97.5
197	6733-6735	0.065	100
193	6736-6739	0.0675	100
199	6740-6743	0.0605	122
331	6744-6747	0.069	104
DG 69	6748-6749	0.170	commercial lubricant
0010	6750-6751	0.095	commercial lubricant
322	6752-6755	0.105	54
323	6756-6759	0.0825	62.5
324	6760-6763	0.087	70
325	6764-6767	0.076	55
326	6768-6771	0.095	66
327	6772-6775	0.073	85
328	6776-6779	0.130	67.5
329	6780-6783	0.0625	62.5
330	6784-6787	0.0945	81
460	6788-6791	0.077	61
461	6792-6795	0.088	67.5
463	6796-6799	0.090	82.5
462	6800-6803	0.118	60
466	6804-6807	0.115	97.5
467	6808-6811	0.094	105
464	6812-6815	0.082	111
465	6816-6819	0.088	84
468	6820-6823	0.140	123
518	6824-6827	0.067	99
520	6828-6831	0.088	106
521	6832-6835	0.093	4
523	6836-6839	0.090	100
516	6840-6843	0.116	136
517	6844-6847	0.140	124
519	6848-6851	0.114	125
522	6852-6855	0.098	120
499	6856-6859	0.143	130
500	6860-6863	0.171	130
501	6864-6867	0.196	120

The above data were successfully used by A. O. Smith to rank their lubricants and run extensive tests using real forgings.

II.D. HIGH TEMPERATURE ENVIRONMENT CHAMBER FOR THE FORGE PRESS - V. Jain

High temperature materials such as titanium aluminides are processed using TZM dies. TZM is an oxidizing material and therefore needs an inert environment for its use at high temperature. In order to enhance the capability of the Lombard forge press to forge aluminides using TZM dies, a high temperature inert environment chamber was designed and developed.

Design Details

A single-walled 16-3/4-in. x 17-in. x 31-in.-high stainless steel chamber, water-cooled at critical locations, was developed and designed. The chamber will be used at about 1700°F and maintain an inert environment at a pressure of 0.10 psi. The chamber is equipped with a number of accessories to facilitate the measurement of temperature, supply power to heater, view specimen, etc.

The high temperature chamber was fabricated with 5/16-in.-thick plates of type 316L stainless steel screwed on a frame made by welding 1-1/2-in. x 1-1/2-in. x 1/4-in.-stainless steel (316L) angles. The joint surfaces of the plates were milled and sealed with a high-temperature (650°F) RTV silicone glue. The chamber is provided with legs to mount it on the press bed. Two heating blocks are provided, the upper and the lower, to heat the die stacks. The lower platen of the press is fixed and the upper one moves with a travel of about 5 in. The upper die stack is mounted on a polished hollow cylinder that enters the chamber through an opening and slides against a Viton-Teflon seal to prevent the inert gas leakage. The seal is water-cooled to prevent heat damage. A 9-in. x 9-in.-opening, covered with a door, has been provided to access the dies. Sealing of the door is provided by an O-ring and the area around the ring is water-cooled to prevent the heat damage to the ring. One viewport protected by a shutter is provided on the front side to view the samples. Since the chamber will be used at about 1700°F, the inside walls were insulated with a 1-1/2-in.-thick sheet of fiber-frax, a high temperature insulating material.

The chamber is equipped with a number of feed-throughs and accessories to facilitate electrical wiring, thermocouple mounting, and pressure control inside the chamber. (See Figure II.D-1.) .

Electrical Feed-Throughs

Four electrical feed-throughs were installed to provide openings for electric wires to supply power to the cartridge heaters.

Thermocouple Feed-Throughs

Four thermocouple feed-throughs have been mounted to provide openings for eight thermocouples. These thermocouples are located at various locations in the upper and lower die stacks to monitor the die and punch temperatures.

Viewport

A viewport has been provided on the front wall to view specimens in the chamber. The viewport is shielded and housing is water-cooled to protect it from heat damage. Space has been provided to mount one more viewport on the back wall if needed.

Gas Inlet Valve

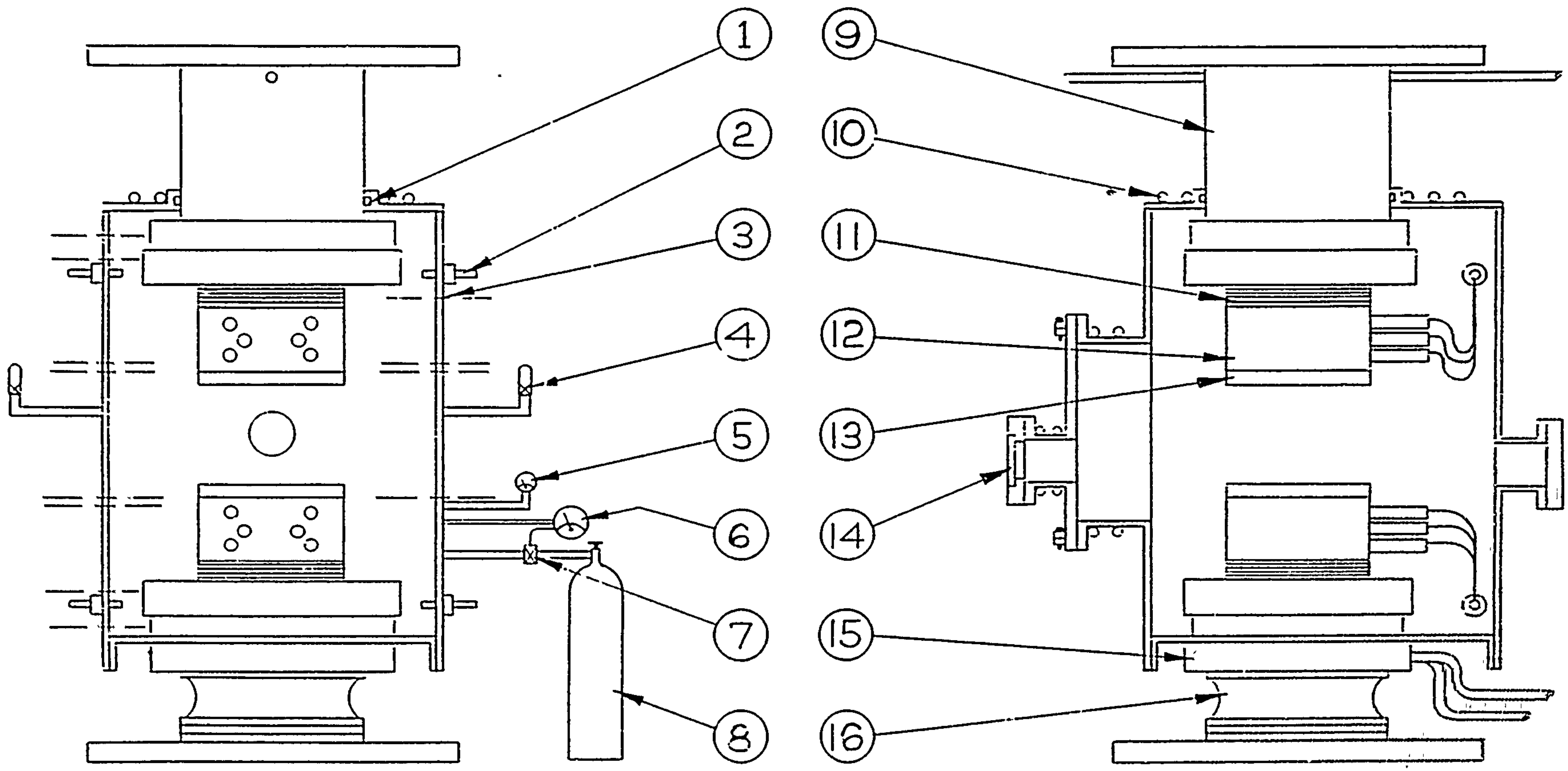
A 2-way inert gas inlet valve has been provided. The valve connects the chamber to an inert gas supply or to the atmosphere.

Pressure Gage

A pressure gage is provided to monitor the chamber pressure. This is a low pressure gage, measuring pressure up to 1 psi.

Photohelic Gage

A photohelic gage has been provided to control the gas pressure in the chamber. This gage will control the pressure at 0.10 psi.



1. Viton-Teflon Seal
2. Electrical Feed-Thru
3. Thermocouple Feed-Thru
4. Pressure Relief Valve
5. Pressure Gage
6. Photohelic Controller
7. Solenoid Valve
8. Inert Gas Sup
9. Water Cooled Cylinder
10. Cooling Coil
11. Insulating Stack
12. Heater Block
13. Die Retainer
14. View Port
15. Cooling Block
16. Load Cell

Figure II.D-1. High Temperature Inert Environment Chamber.

Pressure Relief Valve

A pressure relief valve to operate at 1 psi has been provided to relieve the gas pressure in case of an accident. This valve was specially designed for the chamber since no commercial valve was available for this pressure range.

Safety Considerations

The possible mode of chamber failure is its explosion due to build up of gases inside the chamber. A 1 psi pressure relief valve has, therefore, been provided to exclude the possibility of such an accident.

II.E. BACKUP TOOLING FOR THE EXTRUSION PRESS - V. Jain

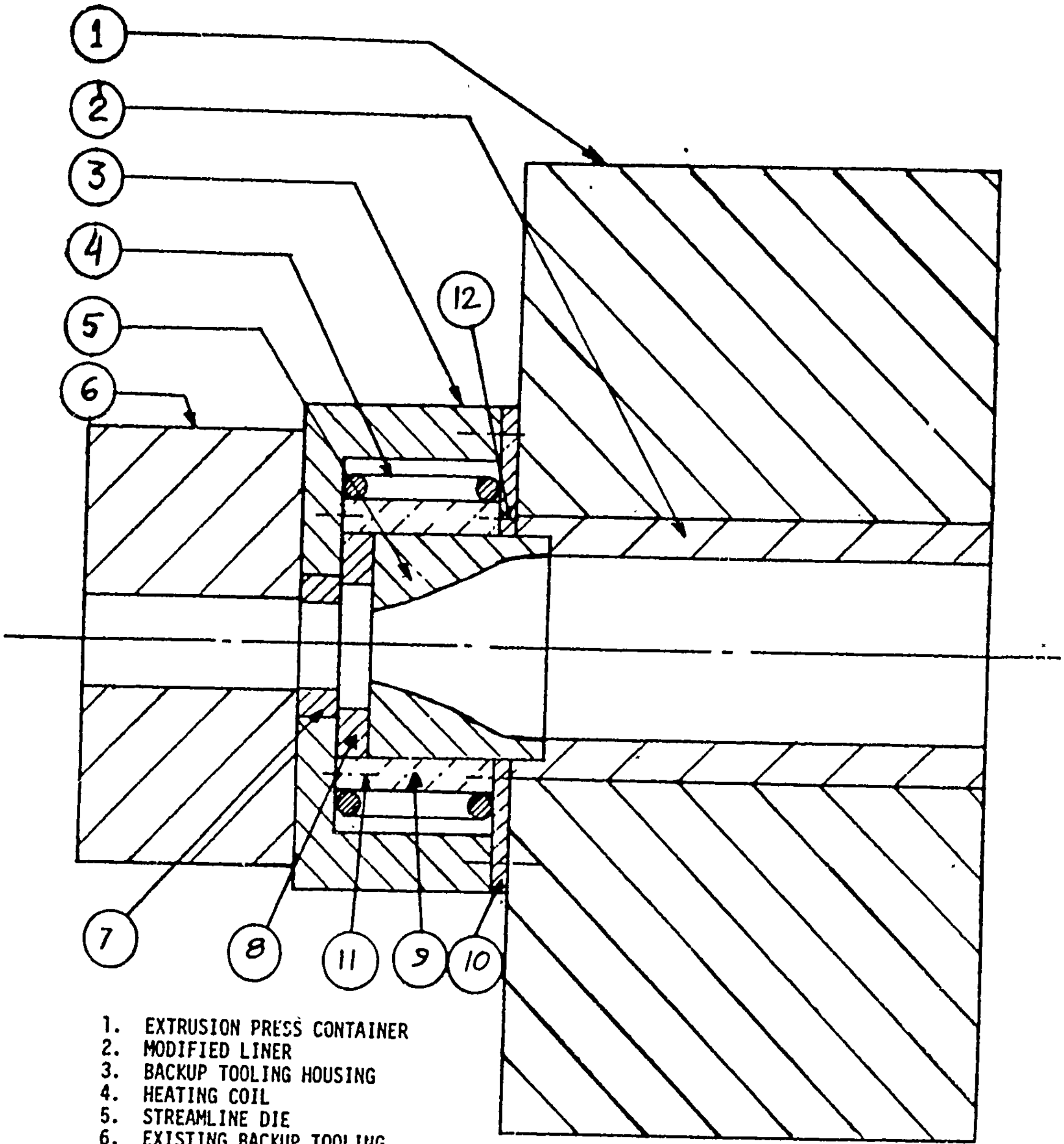
The use of streamline extrusion dies is increasing to obtain better control of material properties. These dies are generally longer than conventional dies with a thin wall at the entrance. The thin wall is the result of restrictions imposed by the liner diameter and extrusion ratio requirement. The thin wall at the die entrance frequently results in folding over during extrusion, damaging the die beyond repair. Using a thick wall-die creates a step in the liner that disrupts the metal flow. Thus, strengthening the die at the entrance necessitates a corresponding change in the container liner. If the inner diameter of the liner is changed, then the existing conventional dies, about 1000 in number, cannot be used. Therefore, a modification to the liner and a design of backup tooling was proposed so that the Lombard extrusion press can be used with both types of dies with minimum amount of effort involved in switching from one type to the other.

Design Upgrade

A design of the backup tooling and modification to the container liner was developed so that the Lombard Extrusion Press could be used with both the streamline and conventional dies. The proposed modification permitted the interchangeable use of the two types of dies as schematically shown in Figures II.E-1 and II.E-2. The following changes were made to the current design.

- Liner was modified as shown in Figure II.E-1.
- A streamline backup tooling was designed, developed, and fabricated (Figure II.E-1).
- A set of rings for backup tooling was machined (Figure II.E-1).
- A set of rings for streamline dies was machined (Figure II.E-1).

The outer and inner diameter of the streamline dies were standardized at 4.0 in. and 3.062 in., respectively. This will provide a die wall thickness at the entrance of approximately 0.50 in., enough to prevent the die edge

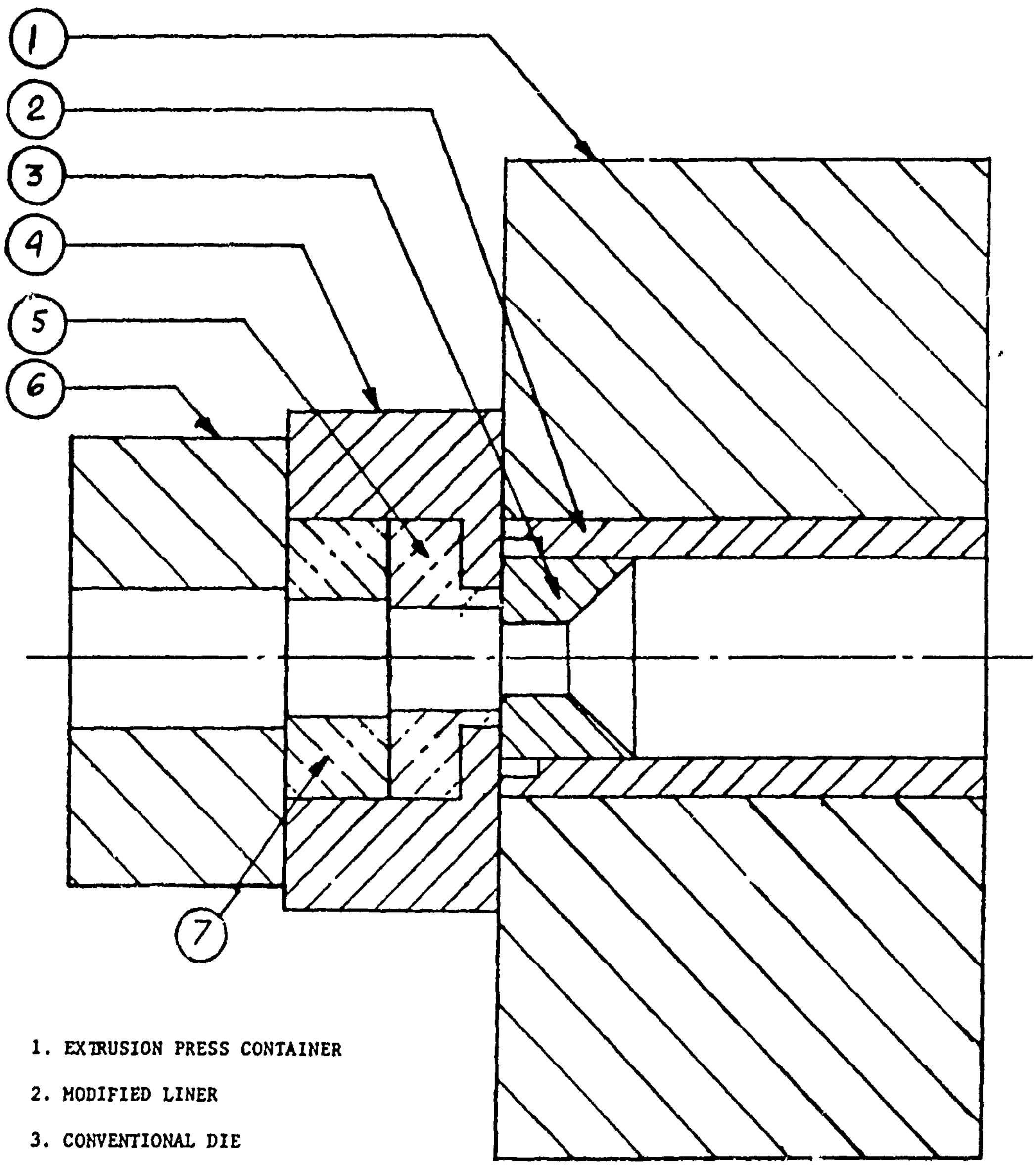


1. EXTRUSION PRESS CONTAINER
2. MODIFIED LINER
3. BACKUP TOOLING HOUSING
4. HEATING COIL
5. STREAMLINE DIE
6. EXISTING BACKUP TOOLING
7. PROPOSED BACKUP RING INSERT
8. BACKUP RING
9. BACKUP TOOLING DIE HOLDER
10. BACKUP TOOLING COVER PLATE
11. FLAT HEAD SCREWS
12. FLAT HEAD SCREWS

BILL OF MATERIALS

PART NO.	REQ'D NO.	STOCK SIZE	MATERIAL
12	24	1/4-20 X 3/4" LONG FLAT HEAD SCREWS	HASTALLOY
11	12	1/4-20 X 1 1/2" LONG FLAT HEAD SCREWS	HASTALLOY
10	1	9" DIA. X 1/2" THICK	H-12 STEEL
9	1	5 1/2" DIA. X 4 1/2" LONG	H-12 STEEL
4	2	HEATING ELEMENTS	HEATUBE
3	1	9" DIA. X 5 1/2" LONG	H-12 STEEL

Figure II.E-1. Schematic of the Proposed Backup Tooling for Streamline Dies.



1. EXTRUSION PRESS CONTAINER
2. MODIFIED LINER
3. CONVENTIONAL DIE
4. EXISTING BACKUP TOOLING
5. EXISTING BACKUP RING
6. EXISTING BACKUP TOOLING
7. EXISTING BACKUP RING

Figure II.E-2. Schematic of the Backup Tooling for Conventional Dies with the Modified Liner.

fold-over. In order to accommodate this increase in diameter, the liner was counterbored to a diameter of 4.0 in. and a depth of 0.75 in. (Figure II.E-1.)

The streamlined die is housed in the backup tooling as shown in Figure II.E-1. It is made of three parts:

- Backup tooling housing.
- Backup tooling die holder.
- Backup tooling cover plate.

These components were machined from H-12 tool steel. The die holder (composite cylinder) is attached to the housing using 12, 1/4-in.-diameter high temperature flat head screws. The composite cylinder was used here so that it can take large amounts of hoop stresses produced during extrusion to prevent die failure. In the annular space formed between the die holder and housing, two heat tube type heating elements, one on each side, are installed to heat up the die to 500°F. These heating elements are similar to those which are currently used to heat up the container. The element leads come out through two slots (0.75 in. x 1.5 in.) machined in the housing. Thermocouples are inserted to measure and control the tooling temperature.

A cover plate is mounted on the top side of the tooling (Figure II.E-1) using 24, 1/4-in.-diameter high temperature screws. This strengthens the die holder and die. An eye bolt is used to facilitate handling of the tooling.

The die inserted in the tooling should protrude about 3/4 in. If the die length is not enough, backup rings will be used to increase its effective length. The top surface of the die will butt against the counter-bored surface of the liner, thus excluding any possibility of material extruding through this joint. A conventional die can be used as usual without making any change to the existing setup (Figure II.E-2). The streamline die can be forced out of the tooling from the back side using a hydraulic press. This new tooling does not need any new mounting device.

Safety Considerations in Design

The housing of the backup tooling has been provided with tapped holes. These holes will be used to mount cages over the heating element leads to prevent any possible electrocution. An eye bolt is used so that the tooling can be handled like the other conventional toolings are handled and that the technician does not have to touch the tooling when it is hot. No other safety problems are involved with this design.

II.F. DATA ACQUISITION AND MANAGEMENT SYSTEMS FOR THE 700-TON LOMBARD EXTRUSION PRESS AT WRDC - I. A. Martorell

Computer applications are widespread. Today computers can be found literally everywhere. Influence of computers can be seen in medicine, testing (in all its general sense), transportation, communications, machining, security systems, business, banking, music, entertainment. Most readers will probably have other other applications to add to the list.

The capability of computers to accurately repeat a task or operation with amazing speed,(1) give computers their wide range of applications. In research this capability makes computers ideal for tasks such as data acquisition, data management and process control.

Use of computers for data acquisition can be economical and result in improvement in the quality of the data, reduction in storage space for large volumes of information and improvements in managing, analyzing and presenting the information. Computers and analog to digital converters can have significantly lower costs and higher reliability than high speed recorders, such as oscillographs, especially when peripheral support equipment and total cycle costs are considered. Nevertheless, software required for a particular application can be expensive and time consuming to develop.

This technical report discusses a data acquisition and management system developed for measuring, storing and displaying loads and displacements for the 700-ton Lombard hydraulic extrusion press at the Metals Processing Laboratory at Wright-Patterson Air Force Base, OH. This system was developed to improve the quality of the data and reduce maintenance cost for the present data gathering system. The system consists of both hardware and software. The hardware consists of a Zenith Z-100 computer, an A/D/A Converter Board, amplifiers, transducers, a printer and a protective enclosure. The A/D/A board from Input/Output Technology, Inc. (Valencia, CA) has eight analog to digital (A/D) channels and eight digital to analog (D/A) channels. Both the A/D and D/A channels have a 12-bit resolution. The A/D channel has a 12 μ s conversion time with a maximum reading rate of

(1)For example, a Cray-1 computer is known to perform 100 million arithmetic operations per s, Scientific American, V. 246, No. 1 (1982).

27,500 readings/s and programmable gains of 0.5, 2, 8 and 32 times. The D/A channel has three programmable voltage ranges: 2.5, 5 and 10 volts. Three of the eight A/D channels are presently in use. One A/D channel is used to measure container temperature; another channel is used to measure ouput of a hydraulic pressure transducer; a third A/D channel is used to measure ram displacement. The hydrualic transducer is a 0-3000-psig pressure transducer from Action Instruments. An Action Instruments strain gage amplifier/ conditioner is used for bridge excitation and signal amplification. The ram displacement is measured with a linear transducer from Houston Scientific. This transducer has an output of 25 mV/V/in. and a total displacement of 40 in. At 10-V excitation, from another Action Instruments strain gage amplifier/conditioner, the output of the transducer is 250 mV/in. of displacement. The computer and support hardware are located in a plexiglass enclosure built on an industrial cabinet for protection against hostile environment in the laboratory. (See Figure II.F-1.) A fan and two filters remove excess airborne particles from the air inside the enclosure.

The software developed consists of two programs: one program is for data acquisition and storage, and the other program is for data management and presentation. All the software was written in Z-BASIC and compiled. The BASIC compiler/linker used is a Microsoft Corporation Copyright program.

Acquisition Program

The acquisition program called EXTRUDE, consists of three main program modules and seven support modules. The three main modules (initialization, measuring and conversion) constitute the main body of the program. These 10 modules are shown in Figure II.F-2.

Initialization

In this module traditional initialization of the program occurs, variables are dimensioned, initial variable values are assigned, operator required information is supplied, etc. The extrusion number, which is automatically updated and stored on the disk after each test, is displayed on the screen.

Fig. II.F-1. Photographs of the Computer and Support Hardware in the Plexiglass Enclosure Built on an Industrial Cabinet.

PROGRAM INITIALIZATION

MEASURING MODULE

CONVERSION MODULE

SUBROUTINES

Measurement of Container Temperature
Determination of Bias for Zero Input to A/D
Set Gain and Measurement Input Voltage to Selected Channel
Convert to Voltage Measurement on Selected Channel
Output Control Word to A/D
Balance Pressure Transducer Circuit
Inspect Output of Displacement Transducer

Fig. II.F-2. Major Program Section of the Data Acquisition Program EXTRUDE.

The operator can accept the computer updated extrusion number or select a number of his own. During the initialization section, the operator enters into the program the billet length and composition, revolutions of the main valve and whether the billet will be extruded or blind die compacted. The program then selects the appropriate readings/s and number of readings. For compaction, the reading rate is set at 6 readings/s for 400 readings, since normally during a blind die compaction, maximum press load is maintained for 60 s. For extrusions, the reading rate and total number of readings are selected based on the length of the billet, opening of the main valve in revolutions and the speed of the ram corresponding to this valve opening. A program option allows the operator to override the reading rate and number of readings selected by the computer. The events occurring during the initialization section are listed in Figure II.F-3.

The ram velocity resulting for a particular opening of the main valve depend on the load resistance of the material being extruded. Lower loads result in higher velocities and very high loads in slower velocities. At very low revolutions of the main valve, the variation in ram speed with load is not very pronounced. At high valve opening the variation in ram speed with load is more pronounced. Variation in ram speed with revolutions of the main valve is shown in Figure II.F-4 for two load levels. The slow ram velocities (VS), which correspond to high extrusion loads, is used to calculate total billet extrusion time (ET) using the original billet length (BL).

$$ET = BL/VS \tag{1}$$

The fast ram velocity (VF), which corresponds to the low extrusion load is used to calculate reading rate based on the billet length and an estimated 100 data points required to plot most curves.

$$RPS = 100*VF/BL \tag{2}$$

The total number of readings is calculated from Eqs. 1 and 2 as readings/s times extrusion time.

DIMENSIONING

SET INITIAL VALUES FOR VARIABLES

DISPLAY EXTRUSION NUMBER

MEASURE CONTAINER TEMPERATURE

OPERATOR REQUIRED INFORMATION

- Extrusion or Compaction
- Composition
- Minimum Trigger Load
- Billet Length
- Revolutions of the Main Valve
- Print Out Every Data Point or Every 25th Point

READINGS PER SECOND, NUMBER OF READINGS AND CYCLES OF DELAY LOOP ARE CALCULATED

OPERATOR EXECUTABLE SUBROUTINES

- Measure A/D Amplifier Bias for Zero Input
- Balance Pressure Transducer Circuit
- Inspect Output of Displacement Transducer

Fig. II.F-3. Major Events During Initialization of Program EXTRUDE.

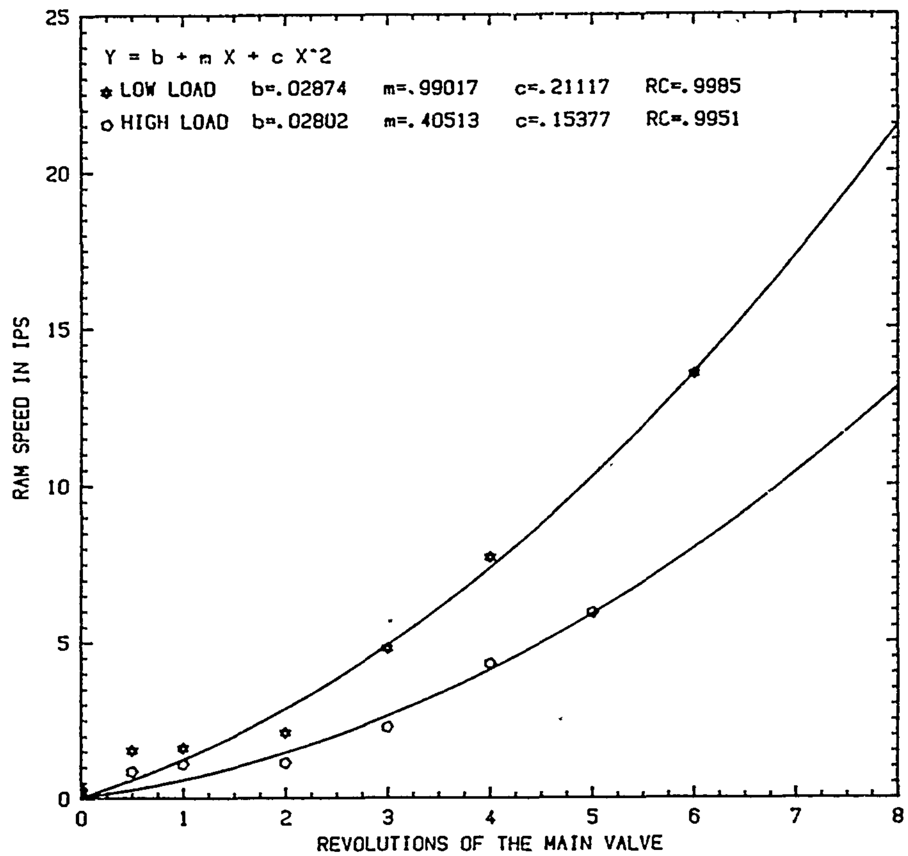


Fig. II.F-4. Ram Speed as a Function of Revolutions of the Main Valve for Two Extrusion Load Levels.

$$IN = 200*VF/VS \qquad (3)$$

The factor of 2 in Eq. 3 is used to insure that enough readings are taken considering the uncertainties of ram speed, material, deformation resistance, billet temperature (including heat loss and adiabatic heating), lubrication, main ram hydraulic pressure, etc. Experience using the program will indicate changes, if any, that may be necessary to factors 100 and 2 in Eqs. 2 and 3, respectively.

A number of other important events also take place during this initial stage of the program. The bias for zero input to the A/D channels is read from file BIAS1.ATD and the container temperature is measured. Program option allows the operator to remeasure the amplifier bias for zero input to the channels, balance the electric circuit of the pressure transducer, examine the output of the displacement transducer, select whether to print a copy of every data point or every 25th point and change the preselected trigger load to initiate the measuring cycle.

Measuring

The measuring section consists of three distinct activities: detection of measuring start signal, measuring the data and delay. At the beginning of the measuring section, the load is continuously measured and compared to the trigger load. When a load larger than the trigger load is detected, the timing cycle is enabled, the interrupt system disabled, and the measuring loop is initiated. The trigger load is preset at 5 tons but a program option during initialization permits selection of a different trigger load.

During the measuring loop, the load, time and displacement are measured once every cycle. Measuring proceeds until the total number of readings calculated by Eq. 3 have been completed. Disabling the interrupt system during the measuring cycle is necessary to avoid erratic time intervals that result when interrupts are acknowledged by the operating system. The interrupt system is again enabled at the completion of the measuring cycle. The desired reading rate determined in the initialization section is maintained through selection of appropriate cycles of a delay loop at the

end of each measuring cycle. The relationship between cycles of the delay loop and readings/s are shown in Figure II.F-5. The maximum reading rate possible with this program is 1070 readings/s.

Conversion

During conversion, the signals measured as 12-bit counts are first converted to voltages. The calibration of the transducer is then used to convert these voltages to load or displacement as appropriate. The load and displacement measurements are timed using the computer's 250 KH clock (Counter 2). The output of the clock is measured as two 8-bit counters, least significant and most significant byte, which represents a maximum of 65,536 counts. Each count is 4×10^{-6} s. Immediately prior to the beginning of the measuring cycle, the counter is loaded with zero's, which represent maximum count. Since the counter is a decreasing counter, every reading will be successively smaller than the previous. As the counter decreases, it reaches zero after 65,536 pulses have elapsed. The counter automatically starts another cycle decreasing again from maximum count. The counter automatically flips to maximum count at zero and continues decreasing. During the time conversion, the two 8-bit bytes are first converted into counts. The number of times the counter crosses zero are determined and the time counts are converted to continuously decreasing sets of numbers with each unit representing 4×10^{-6} s. The time counts are converted to increasing times in s starting with zero for the time of the first reading. A typical example of a time conversion is shown in Table II.F-1. Because the counter decreases from maximum count once every approximately 0.26261 s, the minimum rate possible with this program is approximately four readings/s. This limitation is needed to insure that it will be possible to detect when the counter crosses zero and starts another decreasing cycle. For times between readings larger than about 0.26261 s a different counter or different programming must be used.

After each set of readings is converted, they are printed and stored on file on floppy disk. When the conversion loop is completed, the container temperature and a code to identify a compaction or an extrusion are stored at

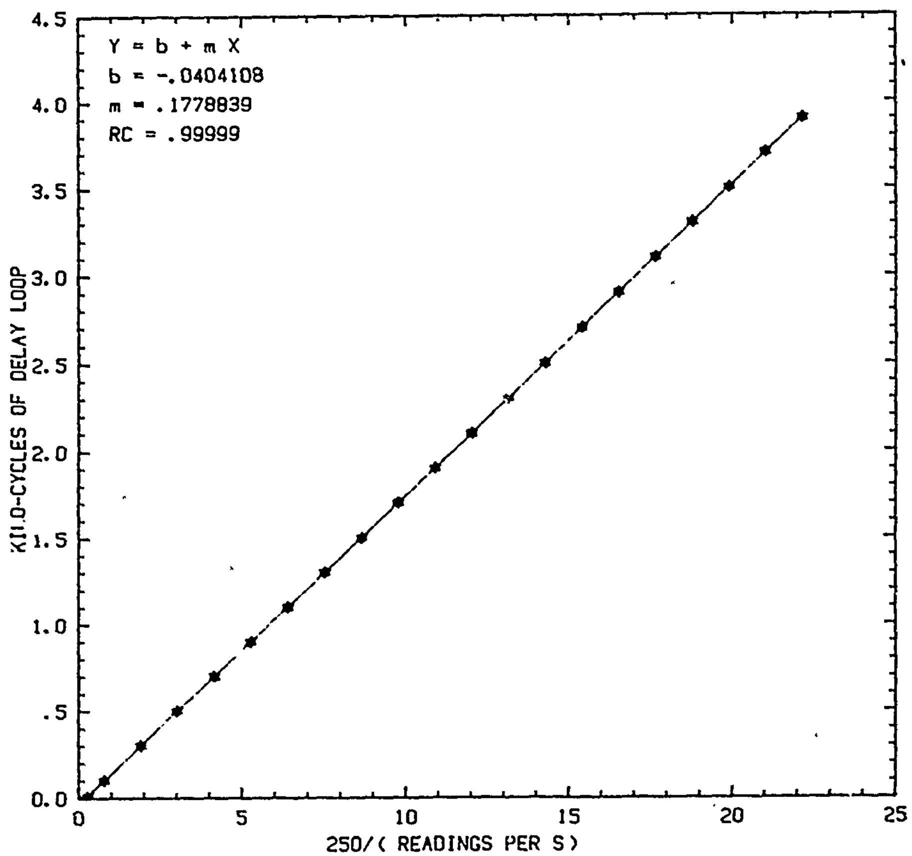


Fig. II.F-5. Cycles of the Delay Loop in Thousands as a Function of the Inverse of Readings Per Second.

TABLE II.F-1: TIME CONVERSION SEQUENCE FOR PROGRAM EXTRUDE USING THE 250 KHZ COUNTER OF Z-100 PC

READING	HIGH BYTE	LOW BYTE	TICKS	RELATIVE DECREASING TICKS	ABSOLUTE INCREASING TICKS	TIME INTERVAL (s)	TIME (s)
1	251	158	64414	719774	0	----	0
2	202	196	51908	707268	12506	0.05002	0.05002
3	153	233	39401	694761	25013	0.05002	0.10005
4	105	15	26895	682255	37519	0.05002	0.15008
5	56	52	14388	669748	50026	0.05002	0.20010
6	7	89	1881	657241	62533	0.05002	0.25013
7	214	125	54909	644733	75041	0.05003	0.30016
8	165	164	42404	632228	87546	0.05002	0.35018
9	116	203	29899	619723	100051	0.05002	0.40020
10	67	239	17391	607215	112559	0.05003	0.45024
11	19	21	4885	594709	125065	0.05002	0.50026
12	226	58	57914	582202	137572	0.05002	0.55029
13	177	95	45407	569695	150079	0.05002	0.60032
14	128	132	32900	557188	162586	0.05002	0.65034
15	79	170	20394	544682	175092	0.05002	0.70037

the beginning of the file. The reading is calculated and printed. The extrusion number is updated and stored on file BIAS1.ATD.

The rest of the program consists of subroutines executable during the three main sections of the program discussed above. These subroutines or program modules are vital for program execution. Subroutines are shown in Figure II.F-6.

Plotting Program

The data managing and presentation program, called PLOTING, is used to delete unwanted data from the data files produced with data acquisition programs for the extrusion, mechanical and forge presses and to create graphs from the data. The program consists of the main program section and a series of subroutines or program modules each with a particular purpose. Like program EXTRUDE, this program is also written in Z-BASIC and compiled. The principal program modules are shown in Figure II.F-6.

Two program modules are used for deletion of data from the files. One module is used to delete unwanted data from extrusion files, another module is used to delete data from mechanical press files. A third deletion module will be added to delete unwanted data from forge press files when program FORGE is completed. The data to be deleted is chosen from a plot of load and displacement vs time by selecting the time coordinate for the beginning of data deletion. A vertical line is drawn through the plot at the selected coordinate. All data to the right of the vertical line will be deleted, or the vertical line can be moved to another location if desired. (See Figure II.F-7.) If the deletion option is exercised, the data is not deleted from the original file but from a file copy. The original file is renamed with a file extension ORG and saved. After the desired data has been deleted, the original file can be destroyed or saved. The data deletion module is automatically executed the first time the file is read. When the module is executed once, the file is coded so that during subsequent attempts to plot the file, the data deletion module will not be automatically executed. A program allows the deletion module to be executed during subsequent readings of the file.

MAIN PROGRAM MODULES

- Initialization
- Clean-out Cycle for Mechanical Press
- Clean-out Cycle for Extrusion Press
- Activity Selection Module

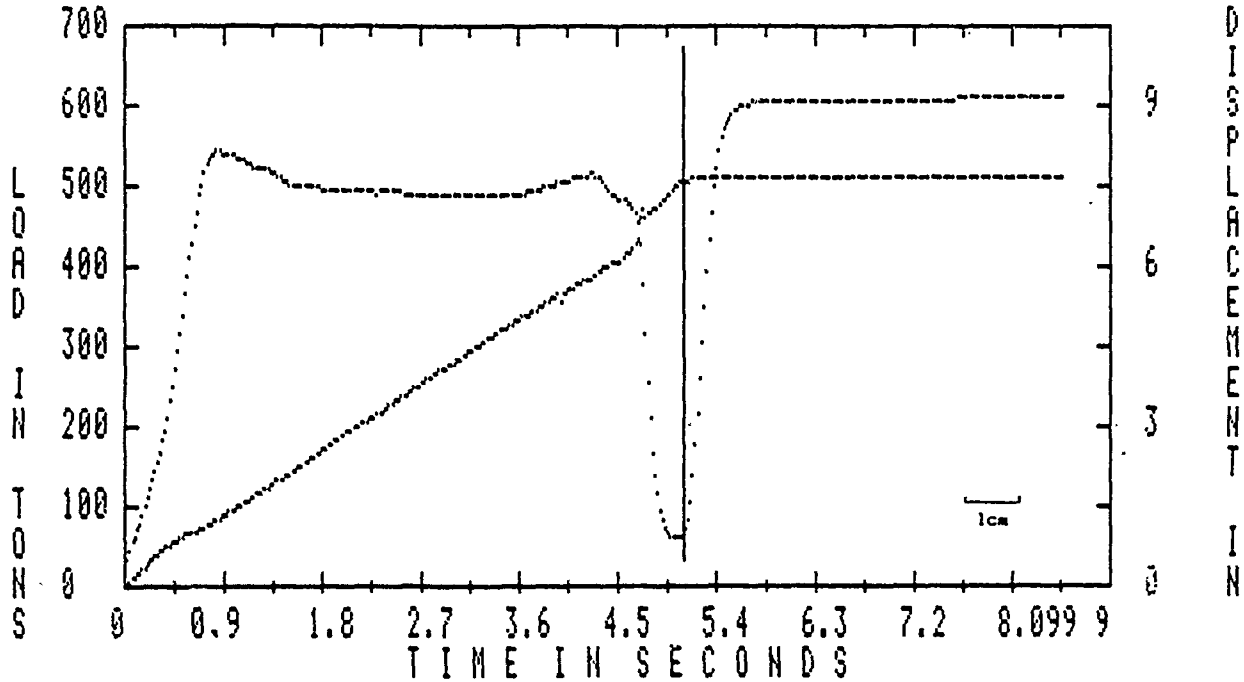
SUBROUTINES

Read Data and Determine

- Maximum Displacement
- Maximum Time
- Maximum Velocity
- Calculate Tick Spacing

- Display Data on the Screen or on the Printer
- Plot Load vs Time and Displacement vs Time
- Plot Load vs Time and Velocity vs Time
- Plot Load vs Displacement
- Plot Both Curves
- Change Label Location
- Change Limits for Regression
- Replot a Portion of Load vs Time Curve

Fig. II.F-6. Modules and Subroutines of Data Presentation Program PLOTING.




```
ENTER TIME IN SECONDS TO START DATA DELETION.
? 5.1
DELETE DATA TO THE RIGHT OF THE LINE?Y OR N
? Y
DO YOU WANT TO DESTROY THE ORIGINAL DATA FILE? Y OR N.
?
```

Fig. II.F-7. Plot of Extrusion Load as a Function of Time used for Deletion of Unwanted Data from File Copy. Data to the Right of Vertical Line will be Deleted.

Four plotting options are available in the activity selection module. The first three graphs are each plotted on a single sheet of paper. Two graphs consist of two curves each. In the first graph, load and displacement are plotted vs time. In the second graph, load and velocity are plotted vs time. The third graph is a curve of load vs displacement. In the fourth choice, the first two graphs (load and displacement vs time and load ad velocity vs time) are plotted on the same sheet. Examples of these four graph options are shown in Figures II.F-8, II.F-9, II.F-10 and II.F-11. All these plots are produced on the screen but can be dumped to the printer by executing shift F12.

The graphs are identified with the extrusion number, average ram velocity, and peak extrusion load. The average ram velocity is calculated as the slope of the least square straight line fit to the displacement time curve. The regression coefficient is calculated and printed next to the average ram velocity.

Other choices available in the activity selection module allow the user to change the location of the labels, to change the limits for the least square fit for calculation of average ram velocity, permit the user to replot a section of the curves being considered, plot another file or stop program execution. Figure II.F-12 shows the five optional locations available for the labels. An example of the replotting option is shown in Figure II.F-13. A copy of the computer screen for the choice of the selection module is shown in Figure II.F-14.

The remaining program consists of support modules with specialized activities required for program execution. These modules include data display module, data read module, plotting modules and plotting parameters setup modules. Use of the plotting program will no doubt result in addition of options to the existing ones. These changes will be evaluated from time to time and incorporated into the program as necessary.

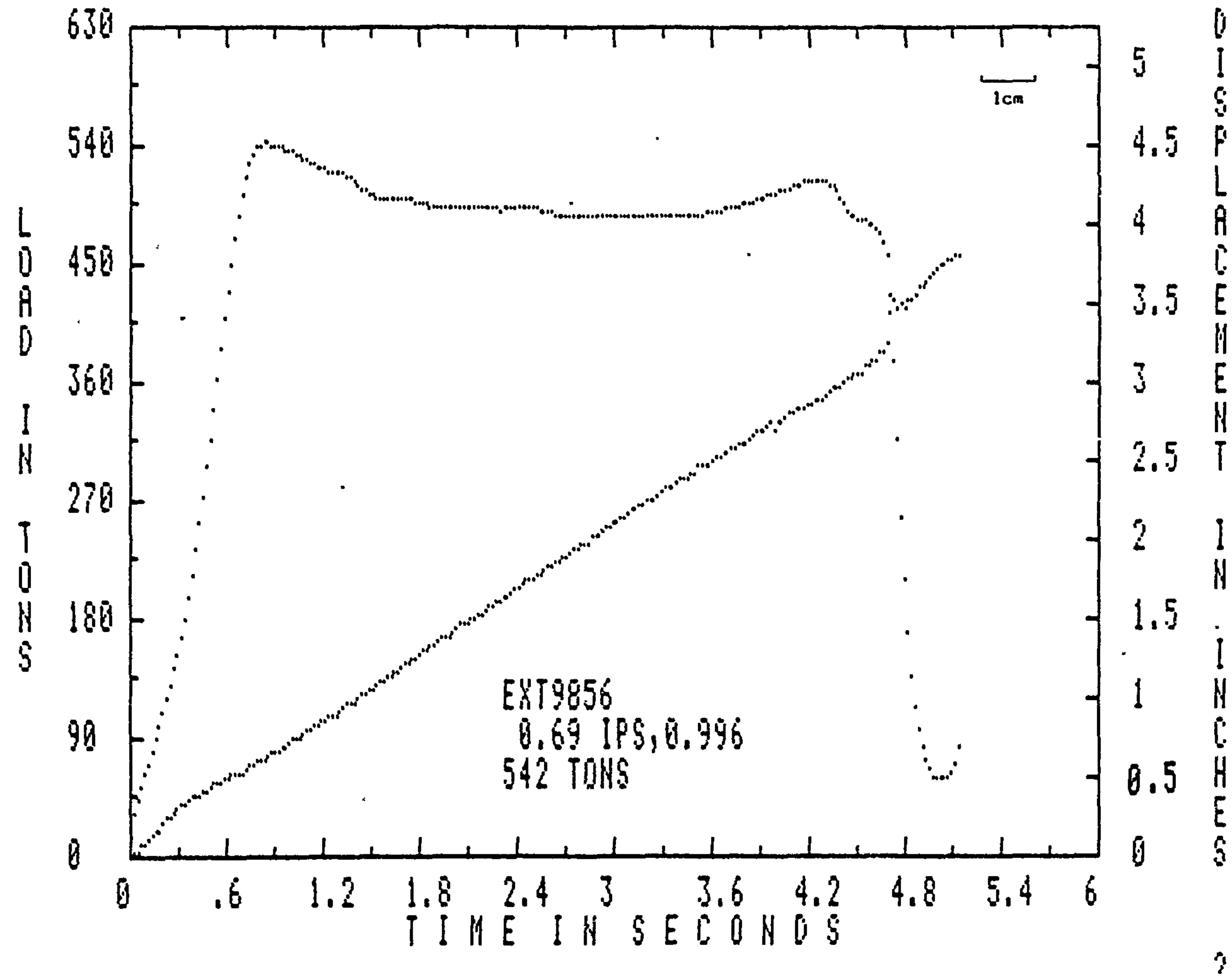


Fig. II.F-8. Extrusion Load and Ram Displacement as a Function of Time. Plotting Option 1.

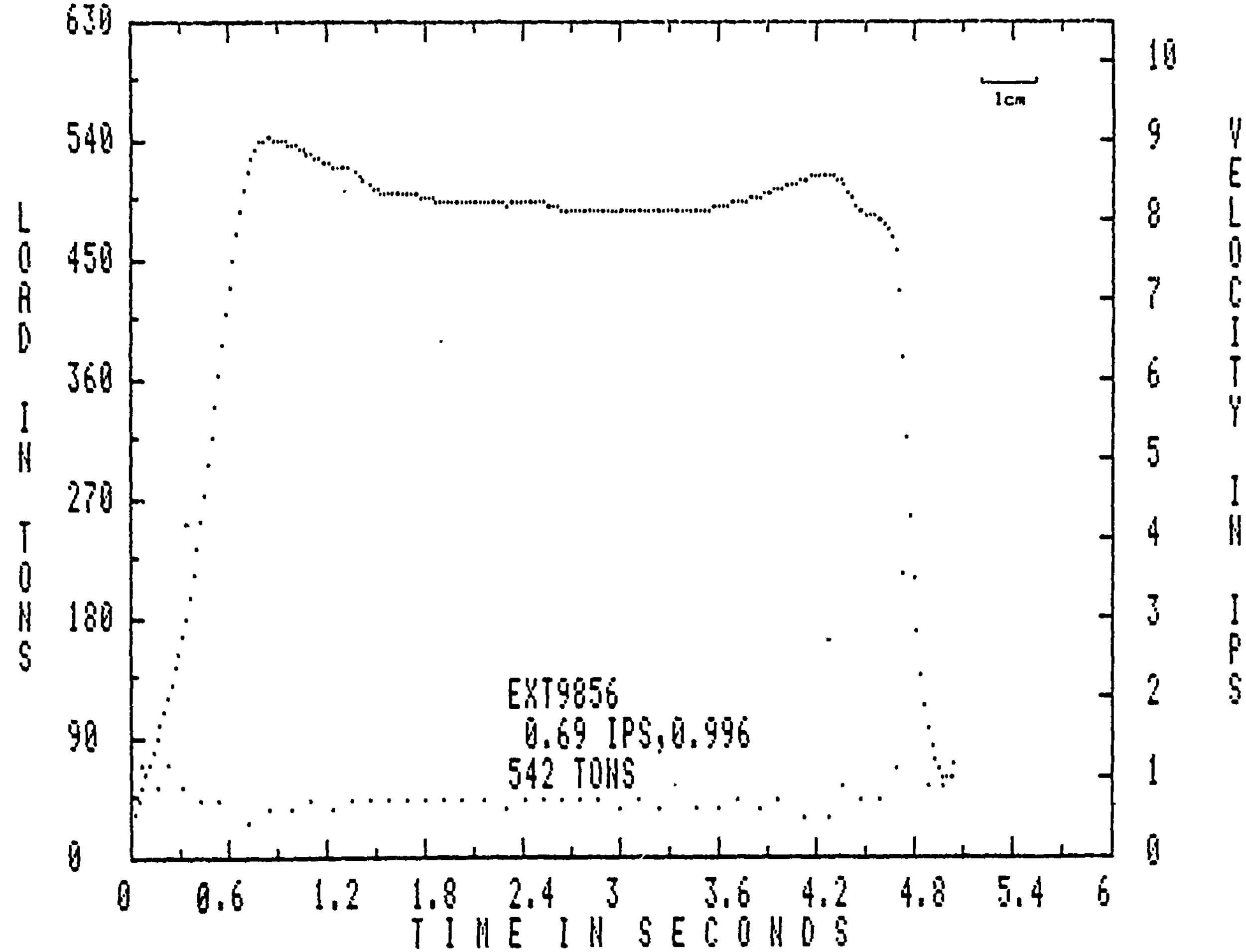


Fig. II.F-9. Extrusion Load and Ram Velocity as a Function of Time. Plotting Option 2.

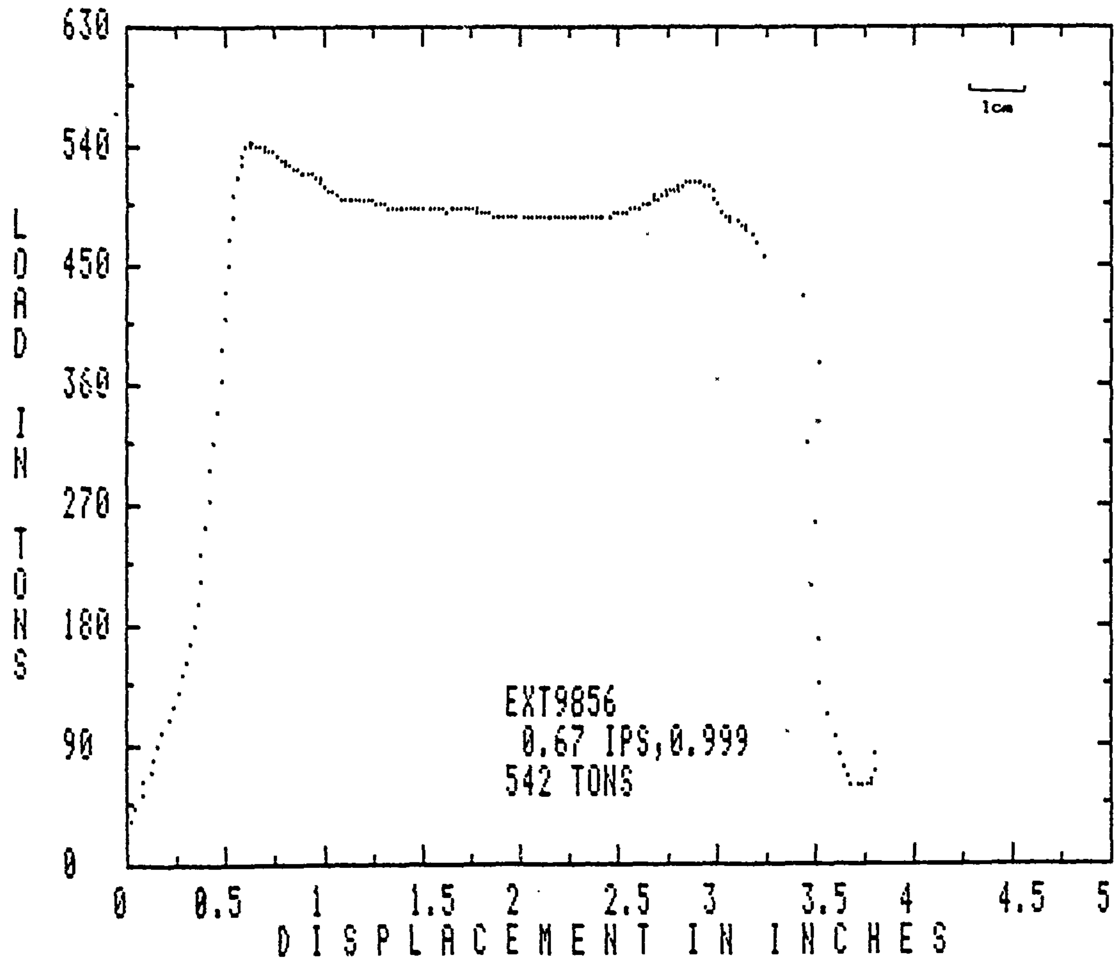


Fig. II.F-10. Extrusion Load as a Function of Ram Displacement. Plotting Option 3.

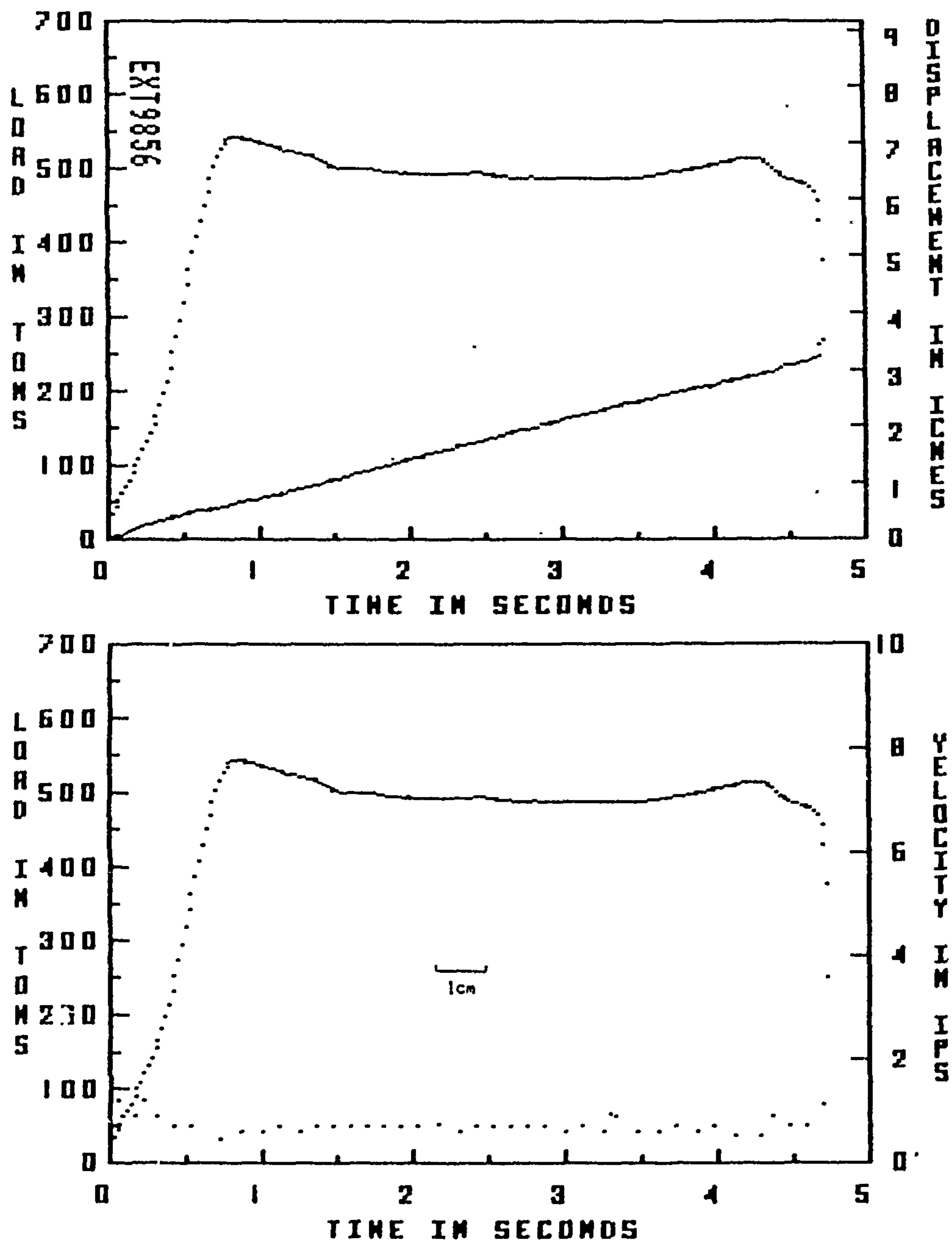


Fig. II.F-11. Both Curves of Plotting Options 1 and 2 on a Single Sheet. Plotting Option 4.

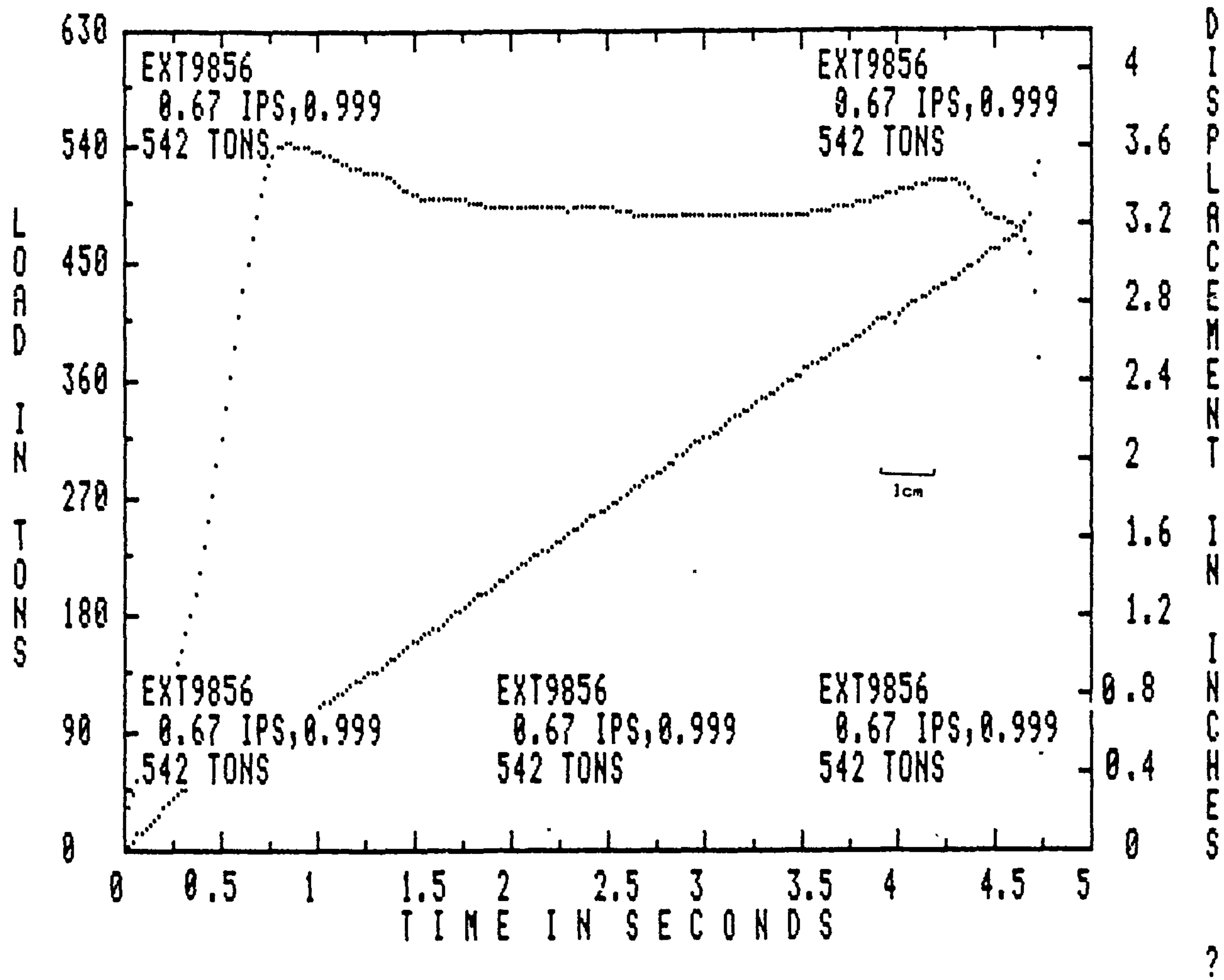


Fig. II.F-12. Five Optional Label Locations Available for Identification of Plotting Options 1 through 3.

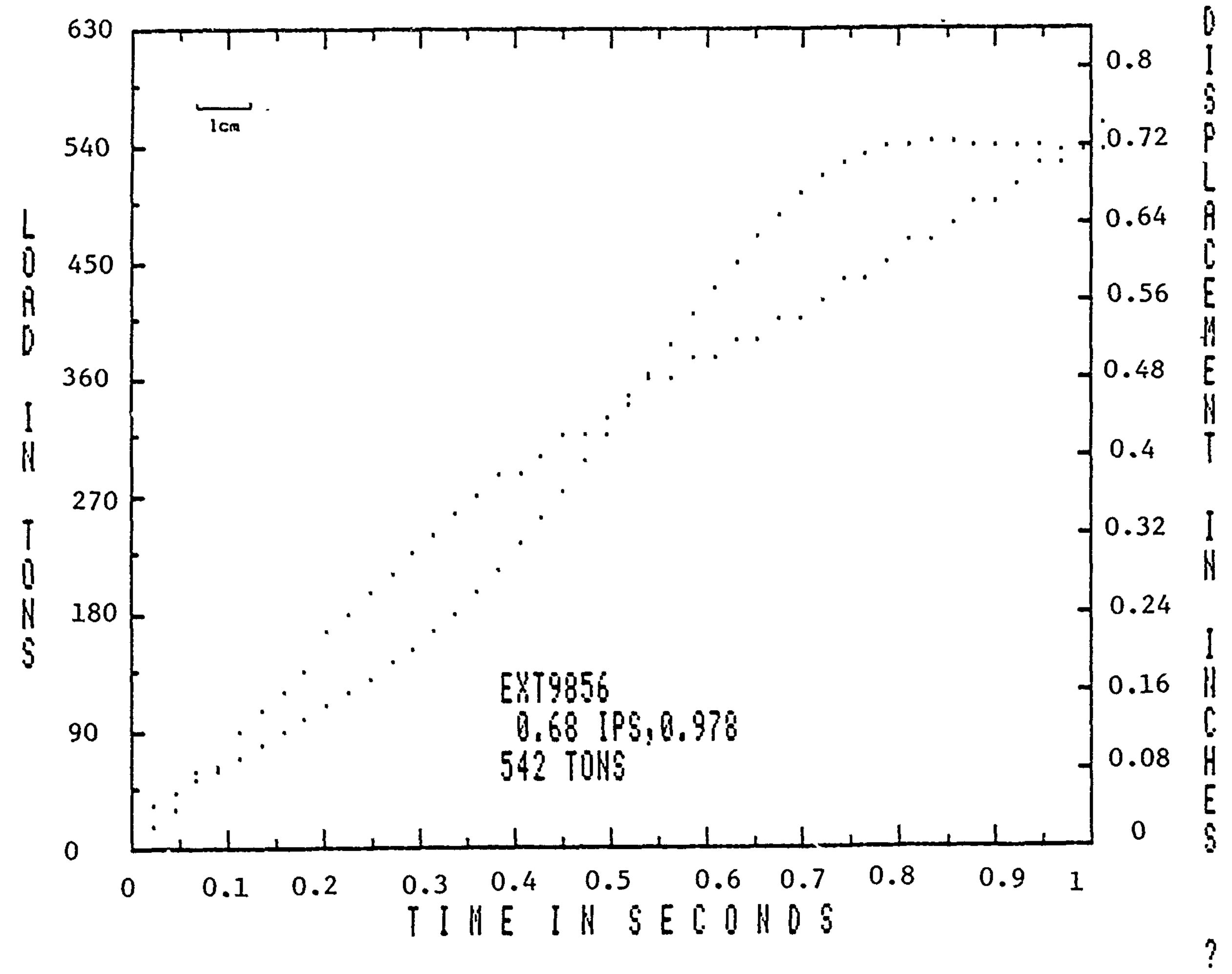


Fig. II.F-13. Portion of Figure F-8 Replotted for 0 to 1 Seconds.

```
SELECT BY NUMBERS
1 TO PLOT LOAD AND DISPLACEMENT VS TIME
2 TO PLOT LOAD AND VELOCITY VS TIME
3 TO PLOT LOAD VS DISPLACEMENT
4 TO PLOT BOTH
5 TO PLOT ANOTHER FILE
6 TO MOVE LABELS
7 TO CHANGE LIMITS FOR THE REGRESSION LINE AND PLOT 1.
8 TO MAGNIFY/DEMAGNIFY AND PLOT 1
9 TO CHANGE THE FILE NAME
10 TO STOP
?
```

Fig. II.F-14. Copy of Computer Screen Showing Choices in Selection Module.

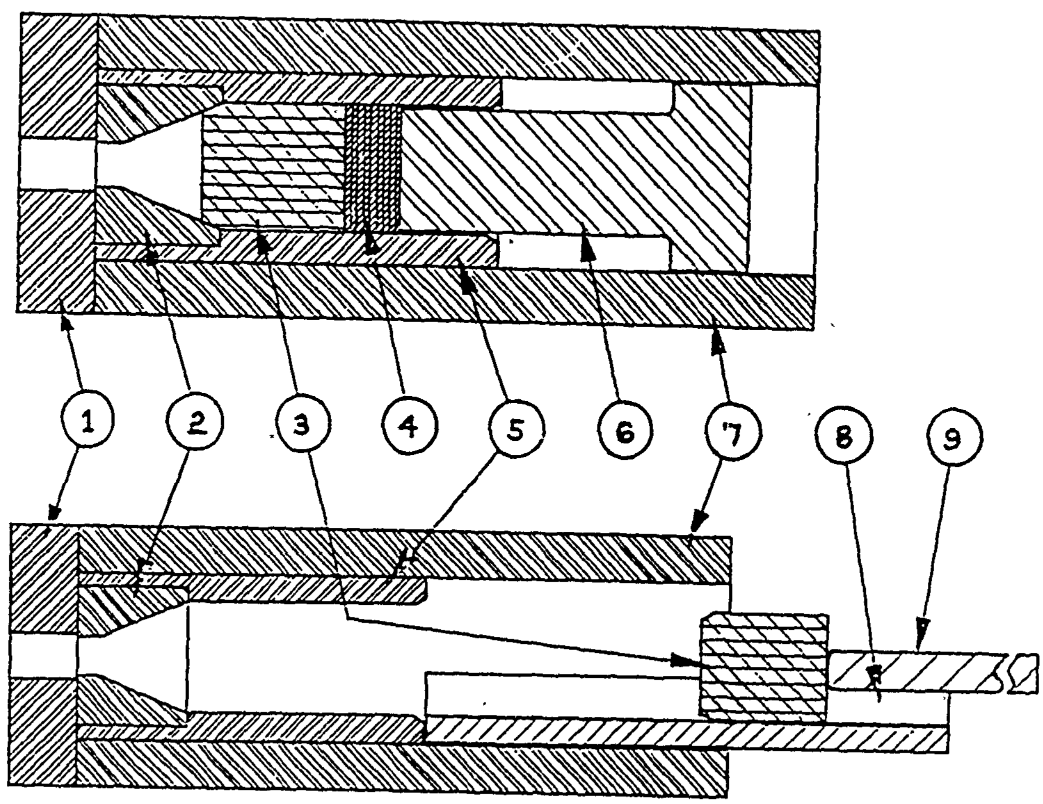
II.G. EXTRUSION AND COMPACTION OF SUBSIZED BILLETS WITH THE 700-TON LOMBARD HYDRAULIC EXTRUSION PRESS - T. E. Jones

In materials research and development, most frequently insufficient amounts of the alloy of interest are available. Each of sufficient quantities severely limit the use of extrusion for compaction and deformation. This is the case at the Processing Laboratory of the Air Force Materials Laboratory at Wright-Patterson Air Force Base, OH. The extrusion press available is a 700-ton Lombard hydraulic press with 3.072-in.-diameter container. Billets and powder-filled cans used are 2.095-in.-outside diameter. These larger diameter cans and billets make use of small amounts of material difficult and expensive. Use of thick-walled extrusion cans may result in increased nonuniformity of deformation, especially when the flow of stress of the can material differs substantially from the flow stress of the material of interest. Thick-walled extrusion cans are expensive to produce because of material and machining costs.

Use of smaller diameter container liners can be expensive and would require a corresponding size change of the extrusion press stem. Size reduction of the main ram can be costly and hazardous if an overload would result in stem failure. Replacement of container liner and stem is time consuming, increases the extrusion press downtime, and ties up personnel in liner and stem replacement operations.

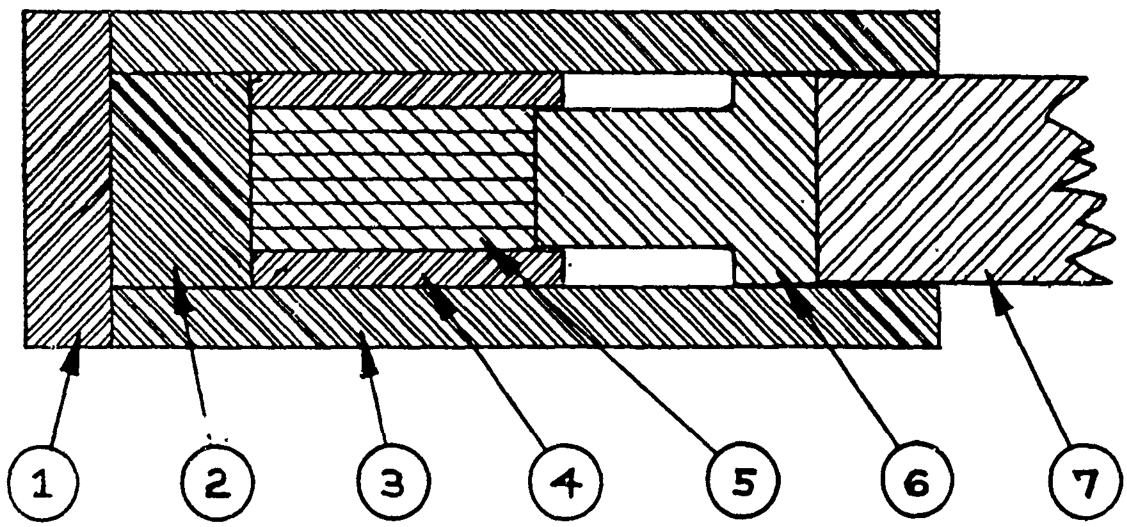
We decided the feasibility for extruding and compacting subsize billets would be of great interest. A secondary liner and stem would nevertheless be as easy to set up as an extrusion die. Furthermore, we thought any possible failure of the secondary stem (or secondary liner) would be contained inside the extrusion press liner, making this operation safer than replacing the 3.072-in.-diameter stem and liner with subsized ones.

Secondary liners and stems for extrusion and compaction of cans 1.875-in.-diameter up to 3-in.-long was designed, built and tested. An assembly drawing for the system is shown in Figures II.G-1 and II.G-2.



1. Backup Tooling
2. Secondary Die
3. Subsize Billet
4. Subsize Carbon Follow Block
5. Secondary Liner
6. Secondary Stem
7. Extrusion Press Container Liner
8. Loading Tube
9. Loading Rod

Figure II.G-1. Assembly Drawing for Secondary Die-Liner-Stem Hardware for Extrusion of Subsize Billets.



1. Backup Tooling
2. Flat Blind Die
3. Container Liner
4. Compaction Can Sleeve
5. Compaction Can
6. Compaction Stem
7. Main Stem

Figure II.G-2. Schematic of a High Pressure Compaction of a Powder Alloy.

The extrusion press at the WRDC Laboratory can deliver 6230 KN (700 tons) to a stem normally 3.010 in. in diameter. This corresponds to a stress on the stem of 1360 MPa (197 ksi). Reducing the stem to 1.940 in. in diameter would increase the stresses on the secondary stem to 3270 MPa (474 ksi).

Two aluminum billets were extruded with the secondary liner and stem. We decided that, with the existing controls now on the extrusion press, the stress on the secondary stem could not be adequately controlled and it would surely result in a failure of the secondary stem and damage the secondary liner.

From the results of the two aluminum billets, we decided from a safety standpoint, that this program should be discontinued until new controls could be installed limiting the load capabilities. Continuing this program at a future date would surely be of extreme value to the research at WRDC.

II.H. MELTING OF MAGNESIUM ALLOYS - T. E. Jones

Induction Melting

Magnesium is an extremely reactive metal. It combines violently with oxygen when molten or hot. As a result it must be melted in a protective atmosphere.

One magnesium melting technique makes use of a protective atm contained in a melting chamber. The chamber is first evacuated to 5 μ and back-filled with argon to about 750 mm of mercury. The process is repeated a second time. The charge for the composition desired is melted by induction in a molybdenum (TZM) crucible. The molten magnesium alloy is poured into a steel mold.

A thermocouple was installed in the vacuum induction melter to measure the temperature of the molten metal. The thermocouple tip was enclosed in graphite to minimize contamination to the magnesium melt. The thermocouple is used to select the power input to the crucible required to pour the melt at the appropriate temperature. Initial power/time requirements for melting aluminum and magnesium have been tentatively determined.

A series of melts was made to determine the degree of cross-contamination between melts and to devise a cleaning procedure. The first melt was a 99.9 percent pure aluminum melt. This sample was analyzed for La, Fe, Ce. These were the additions to the previous melts. The next three melts were for magnesium. These were analyzed for Al, Fe, Ce and La.

Two additional magnesium melts were made to complete the determination of cross-contamination, cleanout procedures and better understanding of power/time requirements for melting magnesium.

After examining chemical compositions of the magnesium melts, we determined that the iron contamination was coming from the magnesium metal used. The aluminum is most likely coming from the previous melts.

Results of analytical chemistry data on various metals indicated that different crucibles should be used for different compositions to minimize contamination. Consequently, redesign of a new crucible system was initiated. This required the use of high density graphite, for the crucibles, together with a system to permit easy replacement of the crucibles.

A total of five Mg-Al binaries and six magnesium alloys were prepared in the induction melting furnace when Westinghouse was instructed not to proceed with the program until inspection was made by the WRDC Safety Officer. As a result, no additional research was done.

Flame Protection Method

As previously stated, magnesium is an extremely reactive metal. Melting of magnesium in air is usually done under fluxes, which keep oxygen away from the reactive magnesium.

The fluxes desired for melting were not immediately available. They were ordered by WRDC/MLLS personnel. Only one type of flux that did not contain lithium was received for use with magnesium alloys.

A flame can be used as protection against oxidation of the magnesium while pouring in air. A reducing flame is used to consume the oxygen in an envelope around the copper mold where the magnesium is poured.

A propane heating torch, mixer, tube and other hardware were ordered. Protective clothing (fire-retardant jackets and leggings) were ordered for this experiment.

As previously agreed, the melting process was demonstrated to the WRDC Safety Officer for approval. The process was demonstrated using aluminum, and the Safety Officer did not approve of the experimental setup. Westinghouse was instructed to discontinue the magnesium melting process.

II.I PREPARATION OF CARBON- AND BORON-CONTAINING ALLOYS - T. E. Jones

Preliminary melting experiments conducted so far indicate that finely divided carbon (not in pieces but sprayed powder, for example) in contact with molten titanium will result in a sample reasonably homogeneous throughout. It is desirable to melt as large a percentage of the total charge volume as possible. For proper selection of the melting parameters (amperage, voltage and time) it is necessary to understand the relationship between volume molten and these parameters. An experiment was designed to obtain this information.

A water-cooled copper mold, 5/8-in.-deep by 2-in.-wide by 6-in.-long, was machined, and a set of Ti-6Al-4V sheets was stacked to fit the cavity. The stack was held together by welding, at the edges, through the thickness, along the length of the stack. The samples were melted at different currents with essentially constant voltage and melting time. The volume of the molten metal was estimated from enlarged photographs of the samples showing the pool. This was to be used to select the melting parameters to prepare samples containing various amounts of carbon and boron by weight.

One melt of Ti-6Al-4V-1.2C was made using the die. The path selected was not correct: less than 50 percent of the volume melted. A modification to the button melter to control travel of the arc was made. A duplicating-like mechanism was installed to allow close control of process parameters during melting. (See Figure II.I-1.)

The stack of Ti-6Al-4V sheets were also modified to hold the stack together better during melting. The edges were welded through the thickness at various places along the length of the stack. An additional improvement to the melting samples was made by welding a piece of welding rod, about 3/4-in.-long, in the position where the center of the melt is desired to start the arc.

A new mold was designed with a double cavity to catch the molten metal during the second pass.

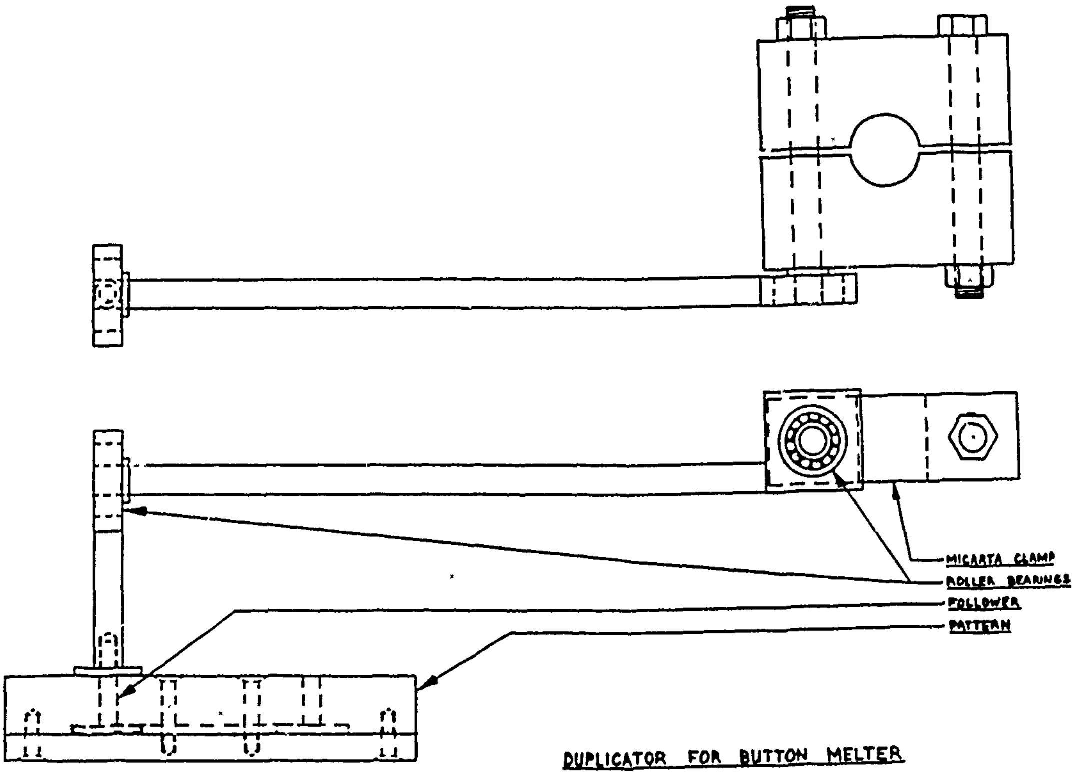


Figure II.I.-1. Duplicating - Line Mechanism for Control of Melting Process.

A Ti-6Al-4V-1.2C sample was prepared. The sample was melted, flipped over, and remelted. The melted portion reached approximately 90 percent. The unmelted portion of the sample was trimmed off, the sample was cut in half, canned and extruded at 982°C and 4:1 area ratio. After the extrusion, the steel can was removed chemically.

Samples were cut from the nose, center and tail for chemical analysis. Analysis of the extrusion indicated 0.78, 0.86 and 0.85 wt% carbon in the nose, center and tail, respectively. Some iron contamination from the canning material was detected. Iron contamination is believed to be limited to the surface approximately 0.020- to 0.040-in.-deep.

A new mold was designed to melt flat samples that could be cut into strips to be used in the POME machine without the need to extrude or swage. We believed this mold would reduce the time required to produce a sample of an alloy, minimize contamination from temperature exposure and from the canning material, save time and reduce cost. The quotes for machining this mold were received, but we were informed by WRDC/MLLS staff that this program had been de-emphasized and no work was planned for this area in the near future.

II.J. RETECH CONSUMABLE-NONCONSUMABLE INERT ATMOSPHERE BUTTON MELTING FURNACE - T. E. Jones

This furnace was received in Bldg. 51, Room 904, on 12 February 1988 and was moved to Room 905 for installation on 2 June 1988. After power, water and air were connected to the furnace, the pneumatic valve would not operate. The operating pressure of the valve should be 40 psig to 120 psig. We discovered that the 55-psig regulator we had on line was insufficient. We installed a line directly to the base supply at 95 psig and the valve worked. The 120-amp power supply was connected to the furnace; the furnace was evacuated to check the power system; an unsuccessful attempt was made to backfill. The backup valve on the diffusion pump was closed and this time the backfill was successful.

When the pneumatic valve was removed, we discovered it was installed incorrectly. The closed position on switch was open. Manual adjustments were made which corrected the problem.

The furnace was charged with 100 g CP-Ti sponge to make the melt. The furnace had a bad leak rate, which was caused by a leak which was discovered around the stinger. After the stinger was disassembled, scratches and a gouge on the brass ball were found. The scratches were corrected by sanding, after which the stinger was reassembled.

An attempt was made to melt, and the hydraulic line on the stinger became hot. We found that the line was grounded to the holding clamp. The line was insulated rom the holding clamp but the furnace was still grounded. An electrical check was made and it revealed that the crucible was grounded to the chamber.

The Air Force contacted Retech and made arrangements for the lower section of the melt chamber to be returned to have the electrical short corrected.

While the melt chamber was at Retech, the stinger was disassembled and the gouge on the brass stinger ball was repaired. As the support for the turn table was being cleaned, we noticed machine turnings in grease, but could not determine where they came from.

When making melts, we discovered that the swing of the stinger was approximately 6 in. in diameter. As a result, the starting stud in the center of the crucible was beyond the reach of the stinger. The arc was started by lowering the rectifier to the minimum setting and striking it on the crucible or furnace charge whenever possible.

The chamber was returned from Retech on 2 November 1988 and reassembled to the furnace. Electrical checks were run; the furnace was pumped down to 1.0 $\times 10^{-4}$ and CP-Ti was melted. The melt oxidized badly. The ion gage was moved to the chamber side of the air valve and the leak rate was checked on the chamber. The leakup rate was greater than 5 μ per min. A leak check was performed on the furnace and leaks were found around the sight ports and relief valve. When the relief valve was disassembled, a powder-like substance was found in the valve. After the valve was cleaned, reassembled and vacuum checked, the leakup rate was less than 1 μ.

CP-Ti was melted in all six cavities of crucible at 0.5 atmosphere. The oxidation of the melt got progressively worse in each cavity. The furnace was pumped down and a leak check run but no leaks were found. The furnace was backfilled, a melt made, and the melt oxidized.

The furnace was recharged and pumped with the diffusion pump overnight. The pressure before the melt was 7.8 x 10^{-5}. After the melt was made, the button oxidized badly.

A solid line from argon bottle to furnace was installed and a melt made. After approximately 5 min of melting, oxidation formed on the melt. The furnace was shut off and allowed to stand. In approximately 2 h, the furnace went from 0.5 atmosphere to atmosphere.

The relief valve was replaced on the furnace; the chamber was pumped down and backfilled to 0.5 atmosphere. After allowing the furnace to stand overnight no change was observed. A good melt was made at 5 min at 500 amps, 20 volts. Melted CP-Ti in all six cavities of crucible were good. During melting, we found that the lateral motion of the stinger was bulky and tough to manipulate.

The furnace was evacuated, the system vented to atmosphere, and allowed to stand for 2 h. The system was evacuated and went from atmosphere to 7.5×10^{-5} in 1 h.

A leakup rate was performed on the furnace after pumping for 17 h. This was done four times with the starting pressure at approximately 2.0×10^{-5} torr, and at 1 min it was at approximately 9.0×10^{-5} torr, which is a 0.07 μ per min leak rate rise.

A melt of pure niobium was performed in the furnace and sent for chemical analysis. The oxygen content of the button melt was the same as the as-received material.

All tests were satisfactorily completed, and we recommended that the furnace be put into operation.

II.K. GENERAL: POWDER HANDLING FACILITY FOR THE 700-TON LOMBARD EXTRUSION PRESS AT WRDC; 10,000th EXTRUSION - I. A. Martorell and P. M. French

Powder Handling Facility

A new powder handling facility was designed and assembled by Westinghouse personnel.

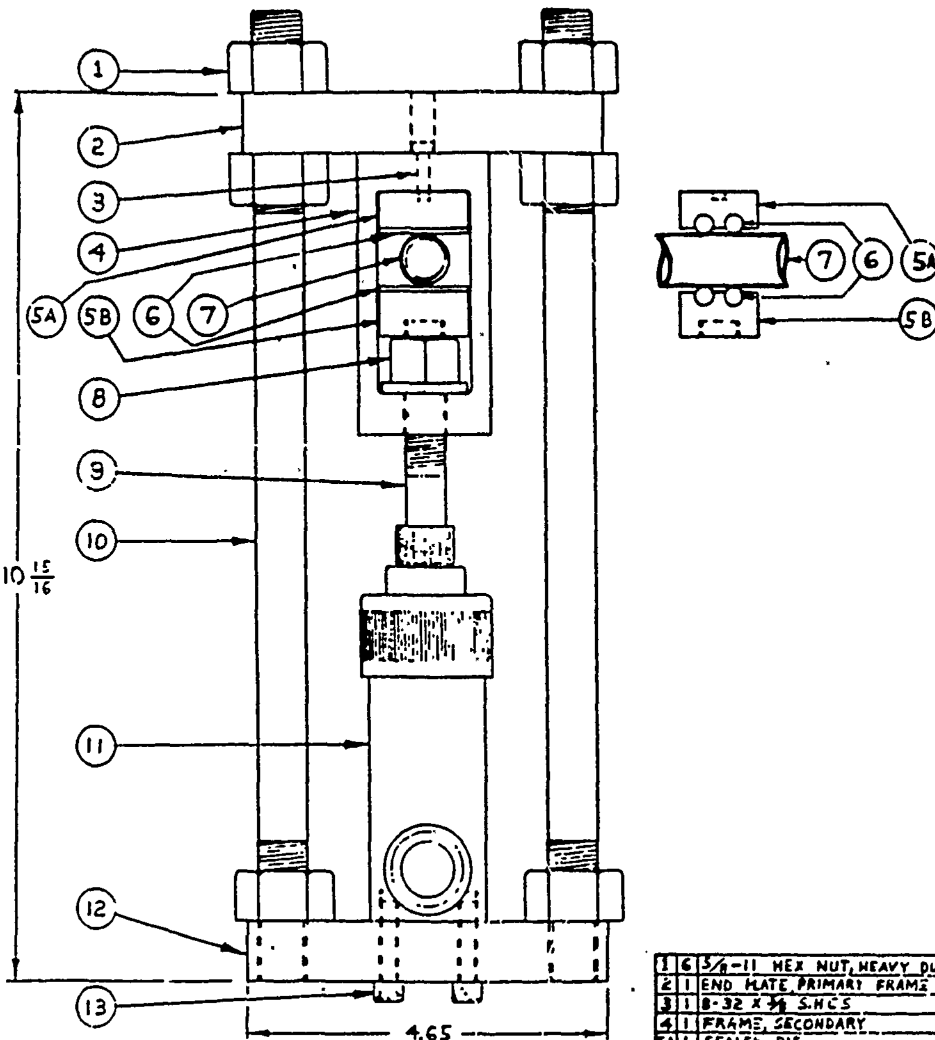
A powder evacuation unit was made to accommodate three heating furnaces for extrusion cans and HIPing tubes.

A glovebox was redesigned for the handling of powder. Flowmeters, photohelic gages, relief valves, and bubblers were incorporated into the system to maintain an atmosphere while handling powders.

The vacuum outgassing and heat treatment section of the new powder handling facility has been assembled, checked out and is fully operational.

A new tool was also designed by Westinghouse personnel for sealing extrusion cans and HIPing tubes. (See Figure II.K-1.) The extrusion can evacuation tube sealer is designed to seal the tubes during the welding operation.

The equipment mentioned above has been assembled, checked out, and is now fully operational.



1	6	5/8-11 HEX NUT, HEAVY DUTY	STD
2	1	END PLATE, PRIMARY FRAME	4340
3	1	8-32 X 3/4 S.H.C.S	STD
4	1	FRAME, SECONDARY	4340
5A	1	SEALER DIE	4340
5B	1	SEALER DIE	4340
6	4	11/64 X 1.175 RODS	D.R.
7	1	EVAC. TUBE, SIZE & MAT. VARIES	
8	1	1/2-13 NUT	STD
9	1	1/2-13 X 2 1/2 S.H.C.S. HEAVY DUTY	STD
10	2	5/8 DIA. X 12" ROD, ENDS 5/8-11 THD	STD
11	1	HYD. CYL., ENERPAC RC-51	STD
12	1	END PLATE, PRIMARY FRAME	4340
13	2	1/4-20 X 1" SHCS	STD
[illegible]	[illegible]	PART NAME	MAT

WESTINGHOUSE AESD, WPAFB, OHIO

TOOL NAME

SEALER, EXTRUSION CAN EVACUATION TUBE

DRAWN BY TMB | SCALE 1-2 1/6

Figure II.K-1. Sealer, Extrusion Can Evacuation Tube.

10,000th Extrusion

One of the major highlights of this contract was the 10,000th extrusion done on the 700-ton Lombard press.

A commemoration ceremony was held at the WRDC Experimental Metals Processing Laboratory on 30 April 1987. The material extruded was Ti-6Al-4V at 982°C with a reduction ratio of 14:1. The extrusion went smoothly and was witnessed by approximately 35 dignitaries representing the Air Force, Westinghouse, and other contractors. The event was highly successful and Westinghouse is proud to be a part of this significant achievement.

III. PHASE II - PROCESSING AND JOINING OF METAL ALLOYS

Experience gained during the performance of the experimental programs outlined in Section II, combined with prior expertise and knowledge of metal forming, has been applied to the processing of more than 3,000 billets and bars of experimental materials related to government and research programs. The processing included extrusion, forging, rolling, swaging, nonconsumable arc melting, induction melting and powder degassing. Materials processed included aluminum, nickel, titanium, magnesium, iron, tungsten, colbalt, tantalum and niobium alloys. A variety of starting material forms were processed: cast, wrought, and powder.

A list of the billets processed by extrusion are included in Table III-1. Data pertinent to the extrusions (such as extrusion temperature, lubricant and ratio) are included.

TABLE III-1 : Billets Processed by Extrusion

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
9551	WRDC/MLLM	10.2:1	C300/Poly	500	Al2124+20V/o-SiC
9552	WRDC/MLLM	10.2:1	C300/Poly	500	Al2124+20V/o-SiC
9553	WRDC/MLLM	15.4:1	C300/Poly	500	Al2124+20V/o-SiC
9554	WRDC/MLLM	15.4:1	C300/Poly	500	Al2124+20V/o-SiC
9555	WRDC/MLLM	11.29:1	C300/Poly	500	Al2124+20V/o-SiC
9556	WRDC/MLLM	11.29:1	C300/Poly	500	Al2124+20V/o-SiC
9557	WRDC/MLLM	4:1	C300/Poly	500	Al2124+20V/o-SiC
9558	WRDC/MLLM	4:1	C300/Poly	500	Al2124+20V/o-SiC
9559	WRDC/MLLM	11.29:1	C300/Poly	475	Al2124+20V/o-SiC
9560	WRDC/MLLM	11.29:1	C300/Poly	475	Al2124+20V/o-SiC
9561	WRDC/MLLM	15.4:1	C300/Poly	475	Al2124+20V/o-SiC
9562	WRDC/MLLM	15.4:1	C300/Poly	475	Al2124+20V/o-SiC
9563	WRDC/MLLM	11.29:1	C300/Poly	475	Al2124+20V/o-SiC
9564	WRDC/MLLM	11.29:1	C300/Poly	475	Al2124+20V/o-SiC
9565	WRDC/MLLM	4:1	C300/Poly	475	Al2124+20V/o-SiC
9566	WRDC/MLLM	4:1	C300/Poly	475	Al2124+20V/o-SiC
9567	WRDC/MLLM	11.29:1	C300/Poly	475	Al2124+20V/o-SiC
9568	WRDC/MLLM	11.29:1	C300/Poly	475	Al2124+20V/o-SiC
9569	WRDC/MLLM	15.4:1	C300/Poly	475	Al2124+20V/o-SiC
9570	WRDC/MLLM	15.4:1	C300/Poly	475	Al2124+20V/o-SiC
9571	WRDC/MLLM	11.29:1	C300/Poly	475	Al2124+20V/o-SiC
9572	WRDC/MLLM	11.29:1	C300/Poly	475	Al2124+20V/o-SiC
9573	WRDC/MLLM	4:1	C300/Poly	475	Al2124+20V/o-SiC
9574	WRDC/MLLM	4:1	C300/Poly	475	Al2124+20V/o-SiC

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^oC)	Composition
9575	WRDC/MLLM	11.29:1	C300/Poly	450	Al2124+20V/o-SiC
9576	WRDC/MLLM	11.29:1	C300/Poly	450	Al2124+20V/o-SiC
9577	WRDC/MLLM	15.4:1	C300/Poly	450	Al2124+20V/o-SiC
9578	WRDC/MLLM	15.4:1	C300/Poly	450	Al2124+20V/o-SiC
9579	WRDC/MLLM	11.29:1	C300/Poly	450	Al2124+20V/o-SiC
9580	WRDC/MLLM	11.29:1	C300/Poly	450	Al2124+20V/o-SiC
9581	WRDC/MLLM	4:1	C300/Poly	450	Al2124+20V/o-SiC
9582	WRDC/MLLM	4:1	C300/Poly	450	Al2124+20V/o-SiC
9583	WRDC/MLLM	20:1	C300/Poly	524	Al-Fe-Ce
9584 9585	GE/EVENDALE	Blank	Poly	1066	Ni-8Co-13Cr-3.5Mo-3.5W-3.5Al-2.5Ti-3.5Cb-.04B-.03C-.03Zr
9586	GE/EVENDALE	Blank	Poly	1066	Ni-8Co-13Cr-3.5Mo-3.5W-3.5Al-2.5Ti-3.5Cb-.01Y-.04B-.03C-.03Zr
9587	GE/EVENDALE	Blank	Poly	1066	Ni-8Co-13Cr-3.5Mo-3.5W-3.5Al-.03C-.03Zr-2.5Ti-3.5Cb-.04B-.20Hf
9588	GE/EVENDALE	Blank	Poly	1066	Ni-8Co-13Cr-3.5Mo-3.5W-.20Hf-3.5Al-2.5Ti-.01Y-.01Y-.04B-.03C-.03Zr
9589	GE/EVENDALE	Blank	Poly	1066	Ni-8Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Cb-.02Hf-.015B-.03C-.03Zr
9590	GE/EVENDALE	Blank	Poly	1066	Ni-8Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Cb-.2Hf-.015B-.03C-.03Zr
9591	GE/EVENDALE	Blank	Poly	1066	Ni-8Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Cb-.2Hf-.03B-.03C-.03Zr

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
9592	GE/EVENDALE	Blank	Poly	1066	Ni-8Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Cb-.2Hf-.015B-.03C-.15Zr
9593	GE/EVENDALE	Blank	Poly	1066	Ni-8Co-13Cr-3.5Mo-3.5W-.20Hf-3.5Al-2.2Ti-3.1Cb-.2Hf-.015B-.03C-.15Zr
9594	GE/EVENDALE	Blank	Poly	1066	Ni-16Co-15Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Cb-.015B-.03C-.03Zr
9595	GE/EVENDALE	Blank	Poly	1066	Ni-12Co-13Cr-3.5Mo-3.5W-3.5Al-2.5Ti-1.5Cb-.2Hf-.015B-.03C-.03Zr
9596	GE/EVENDALE	Blank	Poly	1010	Ni-13Co-16Cr-4Mo-4W-2.1Al-3.7Ti-.7Cb-.2Hf-.015B-.03C-.03Zr
9597	GE/EVENDALE	Blank	Poly	1010	Ni-13Co-16Cr-4Mo-4W-2.1Al-3.7Ti-.7Cb-.2Hf-.015B-.03C-.03Zr
9598	GE/EVENDALE	Blank	Poly	1010	Ni-10Co-15Cr-2Mo-4W 1.5Al-5.5Ti-.015B-.03C-.03Zr
9599	GE/EVENDALE	10:1	8871	704	Ti-10V-2Fe-.2C
9600	GE/EVENDALE	7:1	0010	1093	Ni-8Co-13Cr-3.5Mo-3.5W-3.5Al-2.5Ti-3.5Cb-.06B-.03C-.03Zr
9601	GE/EVENDALE	7:1	0010	1093	Ni-8Co-13Cr-3.5Mo-3.5W-3.5Al-2.5Ti-3.5Cb-.06B-.03C-.03Zr
9602	GE/EVENDALE	7:1	0010	1093	Ni-8Co-13Cr-3.5Mo-3.5W-3.5Al-2.5Ti-3.5Cb-.01Y-.04B-.03C-.03Zr
9603	GE/EVENDALE	7:1	0010	1093	Ni-8Co-13Cr-3.5Mo-3.5W-3.5Al-.25Ti-3.5Cb-.20Hf .04B-.03C-.03Zr

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
9604	GE/EVENDALE	7:1	0010	1093	Ni-8Co-13Cr-3.5Mo-3.5W-3.5Al-2.5Ti-3.5Cb-.20Hf-.01Y-.04B-.03C-.03Zr
9605	GE/EVENDALE	7:1	0010	1093	Ni-8Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Cb-.2Hf-.015B-.03C-.03Zr
9606	GE/EVENDALE	7:1	0010	1093	Ni-8Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Cb-.4Hf-.015B-.03C-.03Zr
9607	GE/EVENDALE	7:1	0010	1093	Ni-8Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Cb-.2Hf-.03B-.03C-.03Zr
9608	GE/EVENDALE	7:1	0010	1093	Ni-8Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Cb-.2Hf-.015B-.03C-.15Zr
9609	GE/EVENDALE	7:1	0010	1093	Ni-8Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Cb-.2Hf-.03B-.03C-.15Zr
9610	GE/EVENDALE	7:1	0010	1093	Ni-16Co-15Cr-3.5Mo-3.5W 3.1Al-2.2Ti-3.1Cb-.015B-.03C-.03Zr
9611	GE/EVENDALE	7:1	0010	1093	Ni-12Co-13-Cr-3.5Mo-3.5W-3.5Al-2.5Ti-1.5Cb-.2Hf-.015B-.03C-.03Zr
9612	GE/EVENDALE	7:1	0010	1038	Ni-13Co-16Cr-4Mo-4W-2.1Al-3.7Ti-.7Cb-.015B-.03C-.03Zr
9613	GE/EVENDALE	7:1	0010	1038	Ni-13Co-16Cr-4Mo-4W-2.1Al-3.7Ti-.9Cb-.02Hf-.015B-.03C-.03Zr
9614	GE/EVENDALE	7:1	0010	1038	Ni-10Co-15Cr-2Mo-4W-1.5Al-5.5Ti-.015B-.03C-.03Zr
9615	WESTINGHOUSE	8:1	0010	649	Ti-10V-2Fe-3Al

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
9616	P&W/FL	15.8:1	7052	1191	Ni-8.9Cr-6.7Al-9.4W-3Ta-1Mo-.15Hf-.02Y
9617	P&W/FL	15.7:1	7052	1227	Ni-8.9Cr-6.7Al-9.4W-3Ta-Mo-.15Hf-.02Y
9618	P&W/FL	15.7:1	7052	1254	Ni-8.9Cr-6.7Al-9.4W-3Ta-1Mo-.15Hf-.02Y
9619	GE/EVENDALE	Blank	Poly	1066	Ni-8Co-13Cr-3.5Mo-3.5W-3C-.03Zr-3.5Al-2.5Ti-3.5Cb-.015B
9620	GE/EVENDALE	Blank	Poly	1066	Ni-12Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Cb-.2Hf-.015B-.03C-.03Zr
9621	GE/EVENDALE	Blank	Poly	1066	Ni-16Co-15Cr-3.5Mo-3.5W-3.5Al-2.2Ti-3.1Cb-.2Hf .015B-.03C-.03Zr
9622	GE/EVENDALE	Blank	Poly	1066	Ni-8Co-10Cr-5Mo-3.5Al-2.5Ti-3.5Cb-.2Hf-.015B-.03C-.03Zr
9623	GE/EVENDALE	Blank	Poly	1066	Ni-17Co-15Cr-5Mo-4Al-3.5Ti-.03B-.06C-.06Zr
9624	GE/EVENDALE	Blank	Poly	1066	Ni-17Co-15Cr-5Mo-3Al-4.8Ti-.03B-.06C-.06Zr
9625	GE/EVENDALE	Blank	Poly	1066	Ni-17Co-15Cr-5Mo-2.1Al-6.2Ti-.03B-.06C-.06Zr
9626	GE/EVENDALE	Blank	Poly	1066	Ni-13Co-16Cr-4Mo-4W-2.1Al-3.7Ti-.7Cb-.03B-.03C-.03Zr
9627	GE/EVENDALE	Blank	Poly	1010	Ni-13Co-16Cr-4Mo-4W-2.1Al-.7Cb-.2Hf-.03B-.03C-.03Zr
9628	GE/EVENDALE	Blank	Poly	1010	Ni-13Co-16Cr-5.5Mo-2.5W-2.1Al-3.7Ti-.7Cb-.015B-.03C-.03Zr-.2Hf
9629	GE/EVENDALE	7:1	0010	1093	Ni-8Co-13Cr-3.5Mo-3.5W-3.5Al-2.5Ti-3.5Cb-.015B-.03C-.03Zr

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
9630	GE/EVENDALE	7:1	0010	1093	Ni-12Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Cb-.02Hf-.015B-.03C-.03Zr
9631	GE/EVENDALE	7:1	0010	1093	Ni-16Co-15Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Cb-.2Hf-.015B-.03C-.03Zr
9632	GE/EVENDALE	7:1	0010	1093	Ni-8Co-10Cr-5Mo-3.1Al-2.5Ti-3.5Cb-.2Hf-.015B-.03C-.03Zr
9633	GE/EVENDALE	7:1	0010	1093	Ni-17Co-15Cr-5Mo-4Al-3.5Ti-.03B-.06C-.06Zr
9634	GE/EVENDALE	7:1	0010	1093	Ni-17Co-15Cr-5Mo-3.Al-4.8Ti-.03B-.06C-.06Zr
9635	GE/EVENDALE	7:1	0010	1093	Ni-17Co-15Cr-5Mo-2.1Al-6.2Ti-.03B-.06C-.06Zr
9636	GE/EVENDALE	7:1	0010	1038	Ni-13Co-16Cr-4Mo-4W-2.1Al-3.7Ti-.7Cb-.03B-.03C-.03Zr
9637	GE/EVENDALE	7:1	0010	1038	Ni-13Co-16Cr-5.5Mo-2.5W-2.1Al-3.7Ti-.7Cb-2Hf-.015B-.03C-.03Zr
9638	GE/EVENDALE	7:1	0010	1038	Ni-13Co-16Cr-5.5Mo-2.5W-2.1Al-3.7Ti-.7Cb-.2Hf-.015B-.03C-.03Zr
9639	WESTINGHOUSE	8:1	0010	982	Ti-10-2-3
9640	WESTINGHOUSE	15.9:1	C300/Poly	399	Al-7091
9641	WESTINGHOUSE	20.4:1	8871	816	Ti-15V-3Al-3Cr-3Sn
9642	WRDC/MLLM	16.34:1	0010	982	Fe-12.5Al-3Hf-7.5Mo-8Ti-.009B-.01Zr
9643	WRDC/MLLM	16:34.1	0010	982	Fe-15.5Al-.45Hf-3.7Mo-3.75Ti-.009B-.10C-.15Si-.25Ti

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
9644	WRDC/MLLM	16.34:1	0010	899	Fe-15.5Al-.45Hf-3.75Mo-3.75Ti-.009B-.10C-.15Sn-.25Ta
9645	WRDC/MLLM	16.34:1	0010	1093	Fe-15.5Al-.45Hf-3.75Mo-3.75Ti-.009B-.10C-.15Si 0.25Ta
9646	WRDC/MLLM	16.34:1	0010	1093	Fe-12.5Al-.3HR-7.5Mo-8Ti-.009B-.1Zr
9647	WRDC/MLLS	4.4:1	0010	871	RST-Alloy Ti-Filament
9648	WRDC/MLLS	4.4:1	0010	871	RST-Alloy Ti-Filament
9649	WRDC/MLLS	4.4:1	0010	871	Fe-72Al-25Ta-2Ti-A/o
9650	WRDC/MLLM	14.03:1	0010	1121	Fe-72Al-25Ta-2Ti-A/o
9651	WRDC/MLLM	14.03:1	0010	1121	Fe-72Al-25Ta-2Ti-A/o
9652	WRDC/MLLM	14.03:1	0010	1121	Fe-72Al-25Ta-2Ti-A/o
9653	US ARMY MTLS	4:1	C300/Poly	357	B_4C/AZ61
9654	US ARMY MTLS	4:1	C300/Poly	357	B_4C/AZ61
9655	WAES/AMMON	7.26:1	0010	1000	Hf-19Ta-3Mo
9656	METCUT/LLS	Blank	C300/Poly	316	Al-8Fe-1.7Ni
9657	METCUT/LLS	Blank	C300/Poly	316	Al-6Fe-6Ni
9658	P&W/FL	11.3:1	7052	1399	Ti-Al
9659	METCUT/LLS	Blank	C300/Poly	343	Al-8Fe-7Ce-.4W
9660	METCUT/LLS	Blank	C300/Poly	343	Al-8Fe-7Ce-.4W
9661	METCUT/LLS	Blank	C300/Poly	343	Al-8Fe-7Ce-.4W
9662	METCUT/LLS	Blank	C300/Poly	343	Al-8Fe-7Ce-.4W
9663	METCUT/LLS	Blank	C300/Poly	343	Al-8Fe-7Ce-.4W
9664	METCUT/LLS	Blank	C300/Poly	343	Al-8Fe-7Ce-.4W

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^oC)	Composition
9665	METCUT/LLS	Blank	C300/Poly	343	Al-8Fe-7Ce-.4W
9666	METCUT/LLS	Blank	C300/Poly	343	Al-8Fe-7Ce-.4W
9667	METCUT/LLS	Blank	C300/Poly	343	Al-8Fe-7Ce-.4W
9668	METCUT/LLS	Blank	C300/Poly	343	Al-8Fe-7Ce-.4W
9669	METCUT/LLS	Blank	C300/Poly	343	Al-8Fe-7Ce-.4W
9670	METCUT/LLS	Blank	C300/Poly	343	Al-8Fe-7Ce-.4W
9671	METCUT/LLS	Blank	C300/Poly	343	Al-8Fe-7Ce-.4W
9672	METCUT/LLS	Blank	C300/Poly	343	Al-8Fe-7Ce-.4W
9673	METCUT/LLS	Blank	C300/Poly	343	Al-8Fe-7Ce-.4W
9674	METCUT/LLS	Blank	C300/Poly	343	Al-8Fe-7Ce-.4W
9675	METCUT/LLS	Blank	C300/Poly	343	Al-8Fe-7Ce-.4W
9676	METCUT/LLS	Blank	C300/Poly	343	Al-8Fe-7Ce-.4W
9677	METCUT/LLS	4.1:1	C300/Poly	372	Al-8Fe-7Ce-.4W
9678	METCUT/LLS	4.1:1	C300/Poly	372	Al-8Fe-7Ce-.4W
9679	METCUT/LLS	4.1:1	C300/Poly	372	Al-8Fe-7Ce-.4W
9680	METCUT/LLS	4.1:1	C300/Poly	372	Al-8Fe-7Ce-.4W
9681	WESTINGHOUSE	4.3:1	0010	982	Ti-6Al-4V-1.2C
9682	METCUT/LLS	4.2:1	C300/Poly	399	Al-8Fe-7Ce-1.4W
9683	METCUT/LLS	4.2:1	C300/Poly	399	Al-8Fe-7Ce-1.4W
9684	METCUT/LLS	4.2:1	C300/Poly	399	Al-8Fe-7Ce-1.4W
9685	METCUT/MLLS	7.13:1	C300/Poly	399	Al-8Fe-7Ce-1.4W
9686	METCUT/MLLS	7.13:1	C300/Poly	399	Al-8Fe-7Ce-1.4W
9687	P&W/FL	11.9:1	7052	1260	Ti-Al
9688	METCUT/MLLS	4.3:1	C300/Poly	385	Al-8Fe-7Ce-.4W

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
9689	METCUT/MLLS	4.3:1	C300/Poly	372	Al-8Fe-7Ce-.4W
9690	METCUT/MLLS	4.3:1	C300/Poly	399	Al-8Fe-7Ce-.4W
9691	(W) MARTORELL	5.5:1	0010	954	410SS
9692	(W) MARTORELL	5.5:1	0010	954	410SS
9693	METCUT/MLLS	11.7:1	C300/Poly	399	Al-8Fe-7Ce-.4W
9694	METCUT/MLLS	11.7:1	C300/Poly	399	Al-8Fe-7Ce-.4W
9695	METCUT/MLLS	11.7:1	C300/Poly	399	Al-8Fe-7Ce-.4W
9696	METCUT/MLLS	20:1	C300/Poly	399	Al-8Fe-7Ce-.4W
9697	METCUT/MLLS	20:1	C300/Poly	399	Al-8Fe-7Ce-.4W
9698	METCUT/MLLS	20:1	C300/Poly	399	Al-8Fe-7Ce-.4W
9699	WRDC/MLLS	16.3:1	0010	1000	Fe-35%Al
9700	WRDC/MLLM	16.3:1	0010	1000	Fe-35%Al
9701	WRDC/MLLM	16.3:1	0010	1000	Fe-35%Al
9702	WRDC/MLLM	16.3:1	0010	1000	Fe-35%Al
9703	METCUT/MLLS	20:1	C300/Poly	372	Al-8Fe-7Ce-.4W
9704	METCUT/MLLS	20:1	C300/Poly	372	Al-8Fe-7Ce-.4W
9705	METCUT/MLLS	12:1	C300/Poly	385	Al-8Fe-7Ce-.4W
9706	WRDC/MLLS	12:1	C300/Poly	385	Al-8Fe-7Ce-.4W
9707	WRDC/MLLS	20:1	C300/Poly	385	Al-8Fe-7Ce-.4W
9708	WRDC/MLLS	20:1	C300/Poly	385	Al-8Fe-7Ce
9709	WRDC/MLLM	16.3:1	0010	1000	Fe-35%Al
9710	WRDC/MLLM	16.3:1	0010	1000	Fe-35%Al
9711	WRDC/MLLN	Blank	Poly	1204	Ti-3Al+Nb
9712	WRDC/MLLN	26.2:1	0010	1204	Ti-3Al+Nb

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
9713	MIT (CORNIE)	17:1	C300/Poly	474	6061Al+2.0%Mg+SiC
9714	MIT (CORNIE)	17:1	C300/Poly	474	6061Al+2.0%Mg-SiC
9715	MIT (CORNIE)	17:1	C300/Poly	474	6061Al+2.0%Mg-SiC
9716	MIT (CORNIE)	17:1	C300/Poly	474	6061Al+2.0%Mg-SiC
9717	MIT (CORNIE)	17:1	C300/Poly	474	6061Al+2.0%Mg-SiC
9718	MIT (CORNIE)	17:1	C300/Poly	474	6061Al+2.0%Mg-SiC
9719	P&W/FL	9:1	0010	1149	Ni-7.5Al-1.78Si
9720	P&W/FL	9:1	0010	1149	Ni-7.5Al-1.78Si
9721	P&W/FL	9:1	0010	1149	Ni-7.5Al-1.78Si
9722	P&W/FL	9:1	0010	1149	Ni-7.5Al-1.78Si
9723	MIT (CORNIE)	17:1	C300/Poly	474	6061Al+2.0Mg+SiC
9724	WESTINGHOUSE	36:1	0010	926	Ti-15V-3Cr-3Sn-3Al
9725	WRDC/ METCUT	Blank	Poly	816	Al_3-TiMLLS
9726	WRDC/ METCUT	Blank	Poly	816	Al_3-TiMLLS
9727	WRDC/ METCUT	Blank	Poly	816	Al_3-TiMLLS
9728	WESTINGHOUSE	7:1	C300/Poly	427	Al-2024
9729	LOCKHEED (CROSSLEY)	20.7:1	7052	1149	HIP-Ti-48Al
9730	LOCKHEED (CROSSLEY)	20.7:1	7052	1149	HIP-Ti-48Al-3Nb
9731	LOCKHEED (CROSSLEY)	20.7:1	7052	1199	HiTi-28Al
9732	LOCKHEED (CROSSLEY)	24.9:1	7052	1249	Ti-30Al

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
9733	LOCKHEED (CROSSLEY)	24.9:1	7052	1249	Ti-26Al
9734	LOCKHEED (CROSSLEY)	20.7:1	7052	1249	Ti-30Al-2Nb
9735	LOCKHEED (CROSSLEY)	D I D N O T E X T R U D E			Ti-30Al-3Nb-2Zr
9736	LOCKHEED (CROSSLEY)	19.2:1	7052	1249	Ti-30A
9737	LOCKHEED (CROSSLEY)	19.2:1	7052	1249	Ti-30Al-3Nb
9738	LOCKHEED (CROSSLEY)	19.2:1	7052	1249	Ti-30Al-3Nb-2Zr
9739	P&W/FL	11.9:1	7052	1260	Ti-Al
9740	P&W/FL	11.9:1	7052	1260	Ti-Al
9741	P&W/FL	10.68:1	7052	1260	Ti-Al
9742	P&W/FL	11.9:1	7052	1260	Ti-Al
9743	GE/KRUEGER	Blank	7052	1066	Ni-11.2Al-11Fe-.24C-.11B
9744	GE/KRUEGER	Blank	Poly	1066	Ni-10.3Fe-7.6Nb-6.2Al-2.3Si-.10B
9745	GE/KRUEGER	Blank	Poly	1066	Ni-10.1Fe-8.3Al-6.0Nb-2.9Hf-.00B
9746	GE/KRUEGER	Blank	Poly	1066	Ni-12.7Al-.11B
9747	GE/KRUEGER	Blank	Poly	1093	Ni-14.9Mo-5.6Al-5.1Co-2.7Cr-2.6Y
9748	GE/KRUEGER	Blank	Poly	1093	Ni-15Mo-5.8Al-5.1Co-2.7Cr-2.6V-1.6Nb-.02B
9769	P&W/FL	12.05:1	0010	1093	Ni-7.48Al-1.30Si-.05B P&W/FL 5.16Fe-3.30Hf

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
9770	GE/EVENDALE	Blank	Poly	1010	Ni-13Co-16Cr-5.5Mo-2.1Al-3.7Ti-2.0Nb-.20Hf-.015B-.02C-.03Zr
9771	GE/EVENDALE	Blank	Poly	1010	Ni-13Co-16Cr-5.5Mo-1.6Al-3.7Ti-3.6Nb-.20Hf-.015B-.02C-.03Zr
9772	GE/EVENDALE	Blank	Poly	1066	Ni-12Co-12Cr-5.12Mo-3.12Al-4.94Ti-.20Hf-.015B-.03C-.03Zr
9773	GE/EVENDALE	Blank	Poly	1066	Ni-11.96Co-12.85Cr-5.08Mo-3.10Al-4.06Ti-1.64Nb-.20Hf-.015B-.03C-.03Zr
9774	GE/EVENDALE	Blank	Poly	1066	Ni-11.92Co-12.80Cr-5.06Mo-2.6Al-4.89Ti-1.63Nb-.20Hf-.015B-.03C-.03Zr
9775	GE/EVENDALE	Blank	Poly	1066	Ni-11.78Co-12.66Cr-.00Mo-2.11Al-4.83Ti-3.23Nb-.20Hf-.015B-.03C-.02Zr
9776	GE/EVENDALE	Blank	Poly	1066	Ni-11.83Co-12.70Cr-5.02Mo-2.59Al-4.01Ti-3.24Nb-.20Hf-.015B-.03C-.03Zr
9777	GE/EVENDALE	Blank	Poly	1066	Ni-8.0Co-13.0Cr-3.5Mo-3.5W-2.6Al-2.7Ti-3.8Nb-.20Hf-.015B-.03C-.03Zr
9778	GE/EVENDALE	Blank	Poly	1066	Ni-8.0Co-13.0Cr-3.5Mo-1.75W-3.1Al-2.7Ti-3.1Nb-.20Hf-.03C-.03Zr
9779	GE/EVENDALE	Blank	Poly	1066	Ni-8.0Co-13.0Cr-3.5Mo-1.75W-3.1Al-2.2Ti-3.0Nb-.20Hf-.015B-.03C-.03Zr
9780	GE/EVENDALE	Blank	Poly	1066	Ni-8.0Co-13.0Cr-3.5Mo-1.75W-2.1Al-2.2Ti-3.1Nb-.20Hf-.027Si-.015B-.03C-.03Zr

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
9781	GE/EVENDALE	Blank	Poly	1066	Ni-17.0Co-15.0Cr-5.0Mo-2.5Al-4.7Ti-1.6Nb-.03B-.06C-.06Zr
9782	GE/EVENDALE	Blank	Poly	1038	Ni-13.0Co-16.0Cr-5.5Mo-2.1Al-3.7Ti-2.0Nb-.20Hf-.015B-.02C-.03Zr
9783	GE/EVENDALE	7.3:1	0010	1038	Ni-13.0Co-16.0Cr-5.5Mo-1.6Al-3.7Ti-3.6Nb-.20Hf-.015B-.02C-.03Zr
9784	GE/EVENDALE	7.3:1	0010	1093	Ni-12.06Co-12.95Cr-5.12Mo-3.12Al-4.9Ti-.20Hf-.015B-.03C-.03Zr
9785	GE/EVENDALE	7.3:1	0010	1093	Ni-11.96Co-12.85Cr-5.08Mo-3.12Al-4.9Ti-.20Hf-.015B-.03C-.03Zr
9786	GE/EVENDALE	7.3:1	0010	1093	Ni-11.92Co-12.80Cr-5.06Mo-2.61Al-4.89Ti-1.63Nb-.20Hf-0.15B-.03C-.03Zr
9787	GE/EVENDALE	7.3:1	0010	1093	Ni-11.78Co-12.66Cr-5.00Mo-2.11Al-4.83Ti-3.23Nb-.20Hf-.015B-.03C-.03Zr
9788	GE/F"ENDALE	7.3:1		1093	Ni-11.83Co-12.70Cr-5.02Mo-2.59Al-4.01Ti-3.24Nb-.20Hf-.015B-.03C-.03Zr
9789	GE/EVENDALE	7.4:1	0010	1093	Ni-8.0Co-13.0Cr-3.5Mo-3.5W-2.6Al-2.7Ti-3.8Nb-.20Hf-.015B-.03C-.03Zr
9790	GE/EVENDALE	7.4:1	0010	1093	Ni-8.0Co-13.0Cr-3.5Mo-1.75W-3.1Al-2.7Ti-3.1Nb-.20Hf-.015B-.03C-.03Zr

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
9791	GE/EVENDALE	7.3:1	0010	1093	Ni-8.0Co-13.0Cr-3.5Mo-1.75W-3.1Al-2.2Ti-4.0Nb-.20Hf-.015B-.03C-.03Zr
9792	GE/EVENDALE	7.3:1	0010	1093	Ni-8.0Co-13.0Cr-3.5Mo 1.75W-3.1Al-2.2Ti-3.1Nb-.20Hf-0.27Si-0.015B-.03C-.03Zr
9793	GE/EVENDALE	7.3:1	0010	1093	Ni-17.0Co-15.0Cr-5.0Mo-2.5Al-4.7Ti-1.6Nb-.03B-.06C-.06Zr
9794	P&W/CT	9.25:1	0010	999	Ni-Al
9795	P&W/CT	9.25:1	0010	999	Ni-Al
9796	WRDC/MLLM	20:1	0010	1149	Ni-25Al
9797	WRDC/MLLM	20:1	0010	1149	Ni-26Al
9798	P&W/FL	4.1:1	0010	982	Ti-14Al-20Nb-4V
9799	P&W/FL	17:1	7052	1228	Ni-8.3Cr-6.6Al-9.7W-3.0Ta-2.0Mo-.10C-.01B-.05C
9800	P&W/FL	17:1	7052	1228	Ni-8.9Cr-6.8Al-9.7W-3.0Ta-1.0Mo
9801	P&W/FL	17:1	7052	1228	Ni-8.9Cr-6.8Al-9.7W-3.0Ta-1.0Mo
9802	P&W/FL	17:1	7052	1357	Ni-8.3Cr-6.6Al-9.7W-3.0Ta-2.0Mo-.10C-.01B-.05Zr
9803	P&W/FL	17:1	7052	1360	Ni-8.9Cr-6.8Al-9.7W-3.0Ta-1.0Mo
9804	P&W/FL	17:1	7052	1360	Ni-8.9Cr-6.8Al-9.7W-3.0Ta-1.0Mo
9805	WRDC/MLLN	Blank	Poly	1204	Ti-16Al-10Nb
9806	WRDC/MLLN	4.25:1	0010	1204	Ti-16Al-10Nb
9807	(W) MARTORELL	4:1	C300/Poly	371	CP-Al

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
9808	(W) MARTORELL	4:1	C300/Poly	RT	CP-Al
9809	(W) MARTORELL	19.27:1	C300/Poly	RT	CP-Al
9810	(W) MARTORELL	4:1	C300/Poly	371	CP-Al
9811	(W) MARTORELL	4:1	C300/Poly	371	CP-Al
9812	(W) MARTORELL	4:1	C300/Poly	371	CP-Al
9813	(W) MARTORELL	4:1	C300/Poly	371	CP-Al
9814	(W) MARTORELL	4:1	C300/Poly	371	CP-Al
9815	(W) MARTORELL	4:1	C300/Poly	RT	Al-6061-T4
9816	(W) MARTORELL	18:1	C300/Poly	RT	Al-6061-T4
9817	(W) MARTORELL	9:1	C300/Poly	RT	Al-6061-T4
9818	(W) MARTORELL	13:1	C300/Poly	RT	Al-6061-T4
9819	(W) MARTORELL	13:1	C300/Poly	RT	Al-6061-T4
9820	(W) MARTORELL	4:1	C300/Poly	RT	Al-6061-T4
9821	(W) MARTORELL	13:1	C300/Poly	RT	Al-6061-T4
9822	(W) MARTORELL	13:1	C300/Poly	RT	Al-6061-T4
9823	(W) MARTORELL	13:1	C300/Poly	RT	Al-6061-T4
9824	(W) MARTORELL	4:1	C300/Poly	371	CP-Al
9825	(W) MARTORELL	4:1	---------	RT	Carbon
9826	(W) MARTORELL	13:1	C300/Poly	RT	Al-6061-T4
9827	METCUT	Blank	C300/Poly	343	Al-6Fe-6Ni
9828	METCUT	Blank	C300/Poly	343	Al-8.2Fe-1.7Co
9829	METCUT	Blank	C300/Poly	260	Al-4.0Fe-4Co
9830	METCUT	4:1	C300/Poly	700	CP-Al
9831	(W) MARTORELL	4:1	C300/Poly	RT	CP-Al

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
9832	(W) MARTORELL	4:1	C300/Poly	RT	CP-Al
9833	(W) MARTORELL	Blank	C300/Poly	343	Al-8.0Fe-1.5C
9834	METCUT	Blank	C300/Poly	343	Al-7.0Fe-6Ce
9835	METCUT	Blank	C300/Poly	343	Al-6.0Fe-6Co
9836					
9837	METCUT	Blank	C300/Poly	343	Al-9.0Fe-4Ce
9838	METCUT	Blank	C300/Poly	343	Al-7Al-3.0Fe-7.0Co
9839	(W) MARTORELL	Blank	C300/Poly	538	Ti-Ribbon
9840	(W) MARTORELL	10:1	Poly	538	1018 Steel
9841	(W) MARTORELL	10:1	Poly	538	1018 Steel
9842	(W) MARTORELL	4:1	Poly	538	1018 Steel
9843	(W) MARTORELL	4:1	Poly	538	1018 Steel
9844	(W) MARTORELL	4:1	Poly	538	1018 Steel
9845	(W) MARTORELL	4:1	Poly	538	1018 Steel
9846	TRW	4.42:1	7052	1238	Ni-9Cr-6.8Al-1Mo-9.4W-3Ta-.15Hf-.1Y
9847	TRW	4.42:1	7052	1238	Ni-9Cr-6.8Al-1Mo-9.4W-3Ta-.15Hf-.1Y
9848	TRW	4.42:1	7052	1238	Ni-9Cr-6.8Al-1Mo-9.4W-3Ta-.15Hf-.1Y
9849	(W) MARTORELL	Blank	C300/Poly	649	Ti-Ribbon
9850	GE/EVENDALE	Blank	Poly	843	Ti-8.0Al-2.8Sn-5.4Hf-3.6Ta-.2Si-1.0Re(Y)
9851	GE/EVENDALE	Blank	Poly	843	Ti-8.0Al-2.8Sn-5.4Hf-3.6Ta-.20Si-1.0Re(Y)
9852	GE/EVENDALE	Blank	Poly	843	Ti-8.0Al-2.8Sn-5.4Hf-3.6Ta-.20Si-1.0Re(Y)

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
9853	GE/EVENDALE	Blank	Poly	843	Ti-6.4Al-3.0Zr-3.2Sn-2.5Hf-1.0Cb-.3Mo-.2Si-3.0Re
9854	GE/EVENDALE	Blank	Poly	843	Ti-6.4Al-3.0Zr-3.2Sn-2.5Hf-1.0Cb-.3Mo-.20Si-3.0Re
9855	GE/EVENDALE	Blank	Poly	843	Ti-6.4Al-3.0Zr-3.2Sn-2.5Hf-1.0Cb-.3Mo-.20Si-3.0Re
9856	GE/EVENDALE	9.6:1	001C	843	Ti-8.0A;-2.8Sn-5.4Hf-3.6Ta-.2Si-1.0Re(Y)
9857	GE/EVENDALE	9.25:1	0010	843	Ti-8.0Al-2.8Sn-5.4Hf-3.6Ta-.20Si-1.0Re(Y)
9858	GE/EVENDALE	9.25:1	0010	843	Ti-8.0Al-2.8Sn-5.4Hf-3.6Ta-.20Si-1.0Re(Y)
9859	GE/EVENDALE	9.25:1	0010	843	Ti-6.4Al-3.0Zr-3.2Sn-2.5Hf-1.0Cb-.3Mo-.2Si-3.0Re
9860	GE/EVENDALE	9.6:1	0010	843	Ti-6.4Al-3.0Zr-3.2Sn-2.5Hf-1.0Cb-.3Mo-.2Si-3.0Re
9861	GE/EVENDALE	9.6:1	0010	843	Ti-6.4Al-3.0Zr-3.2Sn-2.5Hf-1.0Cb-.3Mo-.20Si.30Re
9862	McDONNELL DOUGLAS		9.97:1	0010	1093 Ti-?
9863	McDONNELL DOUGLAS		9.97:1	0010	1093 Ti-?
9864	McDONNELL DOUGLAS		18.7:1	7052	1371 Ti-Al?
9865	P&W/FL	4.5:1	0010	1093	Ti-14Al-20Nb-4V-?
9866	P&W/FL	4.5:1	0010	1093	Ti-14Al-20Nb-4V-?
9867	P&W/FL	4.5:1	0010	1093	Ti-14Al-20Nb-4V-?
9868	P&W/FL	4.5:1	0010	1093	Ti-14Al-20Nb-4V-?
9869	P&W/FL	4.5:1	0010	1093	Ti-14Al-20Nb-4V-?

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
9870	(W) MARTORELL	Blank	Poly	593	Ti-24V-10Cr/Ti-24V-2Er/Ti-2Si-1C Tube
9871	WRDC/MLLN	Blank	Poly	1204	Ti-16Al-10Nb
9872	WRDC/MLLN	4.3:1	0010	1204	Ti-16Al-10Nb
9873	(W) MARTORELL	Blank	Poly	649	Ti-24V-10Cr-1Er
9874	(W) MARTORELL	Blank	Poly	RT	CP-Al
9875	(W) MARTORELL	Blank	0010	649	Ti-24V-10Cr
9876	(W) MARTORELL	4.2:1	C300	RT	CP-Al
9877	GE/EVENDALE	3.75:1	0010	1107	Rene 95
9878	GE/EVENDALE	3.75:1	0010	1121	Rene 95
9879	(W) MARTORELL	Blank	Poly	649	Ti-2Si-1C
9880	GE/EVENDALE	6:1	0010	1107	Rene 95
9881					
9882	(W) BUCKMAN	2.98:1	Hydrograf	RT	Nb
9883	(W) BUCKMAN	2.98:1	Hydrograf	193	Nb
9884	(W) BUCKMAN	2.182:1	C300/Poly	316	Nb
9885	GE/EVENDALE	4:1	0010	1107	Rene 95
9886	GE/EVENDALE	3.5:1	0010	1107	Rene 95
9887	(W) BUCKMAN	Blank	Poly	---	Nb
9888	GE/EVENDALE	Blank	C300/Poly	1010	Ni-18Co-16Cr-5Mo-5W-2.5Al-3Ti-3Nb-.01B-.08C-.05Zr
9889	GE/EVENDALE	Blank	C300/Poly	1010	Ni-13Co-16Cr-4Mo-2.1Al-3.7Ti-.7Nb .2Hf-.02B-.03C-.03Zr-25PPM-Y
9890	GE/EVENDALE	Blank	C300/Poly	1010	Ni-13Co-16Cr-5.5Mo-2.1Al-3.7Ti-2.9Nb-.2Hf .02B-.15C-.03Zr

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
9891	GE/EVENDALE	Blank	C300/Poly	1066	Ni-8Co-19.5Cr-4.3Mo-3Al-3.3Ti-1Nb-.03B-.05C-.05Zr-1.5Ta
9892	GE/EVENDALE	Blank	C300/Poly	1066	Ni-12Co-13Cr-3.5Mo-3.5W--3.1Al-2.2Ti-3.1Nb-.2Hf-.02B-.03C-.03Zr
9893	GE/EVENDALE	Blank	C300/Poly	1066	Ni-12Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Nb-.2Hf-.02B-.03C-.03Zr
9894	GE/EVENDALE	Blank	C300/Poly	1066	Ni-12Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Al-2.2Ti-3.1Nb-.2Hf-.02B-.03C-.03Zr
9895	GE/EVENDALE	Blank	C300/Poly	1066	Ni-8Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-4Nb-.2Hf-.02B-.15C-.03Zr
9896	GE/EVENDALE	Blank	C300/Poly	1066	Ni-8Co-13Cr-3.5Mo-3.5W-3.5Al-2.5Ti-3.5Nb-.02B-.03C-.03Zr
9897	GE/EVENDALE	Blank	C300/Poly	1066	Ni-11.3Al-.11B-10.9Fe
9898	GE/EVENDALE	Blank	C300/Poly	1121	Ni-15Co-10Cr-3Mo-5.5Al-2.2Ti-1.4Nb-.03B-.05C-.05Zr-1VA-2.7Ta
9899	GE/EVENDALE	7.02:1	0010	1038	Ni-18Co-16Cr-5Mo-5W-2.5Al-3Ti-3Nb-.01B-.08C-.05Zr
9900	GE/EVENDALE	7.02:1	0010	1038	Ni-13Co-16Cr-4Mo-4W-2.1Al 3.7Ti-.7Nb-.2Hf-.02B-.03C-.03Zr-.25PPM-Y
9901	GE/EVENDALE	7.02:1	0010	1038	Ni-13Co-16Cr-5.5Mo. 2.1Al-3.7Ti-2.9Nb-.2Hf .02B-.15C-.03Zr
9902	(W) MARTORELL	10:1	C300/Poly	427	CP-Al
9903	GE/EVENDALE	7.5:1	0010	1149	Ni-15Co-10Cr-3Mo-5.5Al-2.2Ti-1.4Nb-.03B-.05C-.05Zr-1Va-2.7Ta

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
9904	GE/EVENDALE	6.9:1	0010	1043	Ni-8Co-19.5Cr-4.3Mo-3Al-3.3Ti-1Nb-.03B-.05C-.05Zr-1.5Ta
9905	GE/EVENDALE	6.9:1	0010	1093	Ni-12Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Nb-.2Hf-.02B-.03C-.03Zr-25PPM-Y
9906	GE/EVENDALE	6.9:1	0010	1093	Ni-12Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Nb-.2Hf-.02B-.03C-.03Zr-50PPM-Y
9907	GE/EVENDALE	6.9:1	0010	1093	Ni-12Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Nb-.2Hf-.02B-.03C-.03Zr-100PPM-Y
9908	GE/EVENDALE	6.9:1	0010	1093	Ni-8Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-4Nb-.2Hf-.02B-.15C-.03Zr
9909	GE/EVENDALE	6.9:1	0010	1093	Ni-8Co-13Cr-3.5Mo-3.5W-3.5Al-2.5Ti-3.5Nb-.02B-.03C-.03Zr
9910	GE/EVENDALE	6.9:1	0010	1093	Ni-11.3Al-.11B-10.9Fe
9911	P&W/FL	12:1	0010	1038	Ni-9.75Al-2.74Si-.05B
9912	P&W/FL	12:1	0010	1038	Ni-5.26Al-7.39Si-.05B
9913	P&W/FL	12:1	0010	1038	Ni-5.3Al-7.2Si-.05B-.05C-.5Ti
9914	P&W/FL	12:1	0010	1038	Ni-8.0Al-4.8Si-1.53Hf-.05B-.103C
9915	P&W/FL	12:1	0010	1093	Ni-8.21Al-1.37Si-.05B-.02C-4.91Nb
9916	(W) BUCKMAN	3.2:1	Poly	732	Nb
9917	P&W/FL	12:1	0010	1121	Ni-7.44Al-4.42Si-1.87Hf-.05B
9918	WRDC/MLLS	30:1	C300/Poly	249	Mg-3Nd-2Mn-1Pr
9919	P&W/FL	10.24:1	0010	1149	Ni-11.87Al-1.77Hf-.05B
9920	P&W/FL	8.3:1		1249	

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
9921	P&W/FL	8.3:1		1249	
9922	P&W/FL	10.9:1		1249	
9923	P&W/FL	10.9:1		1249	
9924	(W) MARTORELL	19.8:1	0010	927	1018 Steel
9925	(W) MARTORELL	3.85:1	Poly	538	1018 Steel
9926	(W) MARTORELL	3.85:1	Poly	538	1018 Steel
9927	(W) MARTORELL	3.85:1	Poly	427	1018 Steel
9928	(W) MARTORELL	3.85:1	Poly	649	1018 Steel
9929	(W) MARTORELL	3.85:1	Poly	760	1018 Steel
9930	(W) MARTORELL	2.98:1	8871	649	1018 Steel
9931	GE/EVENDALE	2.98:1	8871	649	CP-Ti
9932	GE/EVENDALE	6.2:1	0010	760	Ti-24V-10Cr-2Er (Ribbon)
9933	(W) MARTORELL	6.2:1	0010	760	Ti-2Si-1C
9934	(W) MARTORELL	6.2:1	0010	760	Ti-24V-10Cr
9935	WRDC/MLLS	Blank	C300/Poly	204	Mg-3Nd-1Pr-1Mn
9936	WRDC/MLLS	Blank	C300/Poly	204	Mg-3Nd-1Pr-1Mn
9937	WRDC/MLLS	30:1	C300/Poly	149	Mg-3Nd-1Pr-1Mn
9938	WRDC/MLLS	21:1	C300/Poly	149	Mg-3Nd-1Pr-1Mn
9939	GE/EVENDALE	Blank	Poly	843	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.20Si-1.0Re
9940	GE/EVENDALE	Blank	Poly	843	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.20Si-1.0Re
9941	GE/EVENDALE	Blank	Poly	843	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.20Si-1.0Re

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
9942	GE/EVENDALE	Blank	Poly	843	Ti-6.4Al-3.0Zr-3.2Sn-2.5Hf-1.0Cb-.3Mo-.2Si 3.0Re
9943	P&W/HARTFORD	9.07:1	0010	999	Ni-Al-#99
9944	P&W/HARTFORD	9.25:1	0010	999	Ni-Al-#99
9945	GE/EVENDALE	9.2:1	0010	843	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.20Si-1.0Re
9946	GE/EVENDALE	9.2:1	0010	843	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.20Si-1.0Re
9947	GE/EVENDALE	9.2:1	0010	843	Ti-8Al-2.8Sn-5.4Hf-3.6Ta- 20Si-1.0Re
9948	GE/EVENDALE	9.2:1	0010	843	Ti-6.4Al-3.0Zr-3.2Sn-2.5Hf-1.0Cb-.3Mo-.2Si-3.0Re
9949	GE/EVENDALE	8.6:1	0010	982	Ti-25Al-2Nb-.4Er
9950	GE/EVENDALE	8.6:1	0010	982	Ti-25Al-5Nb-.7Er
9951	GE/EVENDALE	8.6:1	0010	982	Ti-25Al-5Nb-5Ta-.4Er
9952	GE/EVENDALE	8.6:1	0010	982	Ti-25Al-5Nb-5Ga-.4Er
9953	GE/EVENDALE	8.6:1	0010	982	Ti-25Al-5Nb-5Ta
9954	GE/EVENDALE	8.6:1	0010	982	Ti-25Al-11Nb-.4Er
9955	McDONNELL-DOUGLAS	19.27:1	7052	1371	Ti-34Al
9956	MARTIN-MARIETTA	4.49:1	7052	1200	Ti-45Al (Atom %)
9957	MARTIN-MARIETTA	4.49:1	7052	1200	Ti-45Al (Atom %)
9958	MARTIN-MARIETTA	4.49:1	7052	1200	Ti-45Al (Atom %)
9959	MARTIN-MA[illegible]TA	4.6:1	7052	1350	Ti-45Al (Atom %)
9960	MARTIN-M[illegible]TA	4.6:1	7052	1350	Ti-45Al (Atom %)
9961	WRDC/M[illegible]	Blank	Poly	204	Mg-3Nd-1Pr-1Mn
9962	P&W/FL	11.4:1	7052	1204	Ti-Al-80 Mesh
9963	P&W/FL	11.4:1	7052	1204	Ti-Al-80 Mesh

TABLE III-1: <u>Billets Processed by Extrusion</u>--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
9964	P&W/FL	11.4:1	7052	1204	Ti-Al-80 Mesh
9965	P&W/FL	11.4:1	7052	1204	Ti-Al-80 Mesh
9966	P&W/FL	11.4:1	7052	1149	Ti-Al-80 Mesh
9967	P&W/FL	11.4:1	7052	1149	Ti-Al-80 Mesh
9968	P&W/FL	11.4:1	7052	1093	Ti-Al-80 Mesh
9969	P&W/FL	10.4:1	7052	1260	Ti-Al-80 Mesh
9970	P&W/FL	10.4:1	7052	1260	Ti-Al-80 Mesh
9971	P&W/FL	10.4:1	7052	1260	Ti-Al-80 Mesh
9972	P&W/FL	10.4:1	7052	1204	Ti-Al-80 Mesh
9973	WRDC/MLLS	13.5:1	C300/Poly	149	Mg-3Nd-1Pr-1Mn
9974	DEMO	7.80:1	7052	954	410 SS
9975	WRDC/MLLM	Blank	Poly	1100	Al-35.6Ti-13.44Ni
9976	WRDC/MLLM	Blank	Poly	1100	Al-25Ti-12Cu
9977	WRDC/MLLM	12.47:1	7052	1100	Al-35.6Ti-13.44Ni
9978	WRDC/MLLM	12.47:1	7052	1100	Al-25Ti-12Cu
9979	WRDC/MLLM	12.47:1	7052	1100	Al-3Ti
9980	WRDC/MLLS	Blank	C300/Poly	250	Mg-3Nd-2Mn-1Pr
9981	WRDC/MLLS	Blank	C300/Poly	250	Mg-3Nd-2Mn-1Pr
9982	WRDC/MLLS	Blank	C300/Poly	260	Mg-3Nd-2Mn-1Pr
9983	WRDC/MLLS	5:1	C300/Poly	150	Mg-3Nd-2Mn-1Pr
9984	WRDC/MLLS	8:1	C300/Poly	150	Mg-3Nd-2Mn-1Pr
9985	WRDC/MLLS	12.3:1	C300/Poly	100	Mg-3Nd-2Mn-1Pr
9986	WESTINGHOUSE	8.3:1	C300/Poly	316	CP-Al
9987	WESTINGHOUSE	8.3:1	C300/Poly	316	CP-Al
9988	WESTINGHOUSE	8.3:1	C300/Poly	316	CP-Al

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	omposition
9989	WESTINGHOUSE	8.3:1	C300/Poly	316	CP-Al
9990	WESTINGHOUSE	8.3:1	C300/Poly	316	CP-Al
9991	WESTINGHOUSE	8.3:1	C300/Poly	316	CP-Al
9992	WESTINGHOUSE	8.3:1	C300/Poly	316	CP-Al
9993	WESTINGHOUSE	8.3:1	C300/Poly	316	CP-Al
9994	WESTINGHOUSE	11.9:1	7052	982	CP-Al
9995	WESTINGHOUSE	11.9:1	C300/Poly	316	CP-Al
9996	WESTINGHOUSE	11.9:1	C300/Poly	316	CP-Al
9997	WESTINGHOUSE	11.9:1	C300/Poly	316	CP-Al
9998	WESTINGHOUSE	11.9:1	C300/Poly	316	CP-Al
9999	WESTINGHOUSE	11.9:1	C300/Poly	316	CP-Al
10,000	WESTINGHOUSE	13.1:1	7052	982	Basic/Ti-6Al-4V
10,001	WESTINGHOUSE	13.1:1	7052	982	Ti-6Al-4V
10,002	WRDC/MLLS	Blank	Poly	593	
10,003	WRDC/MLLS	Blank	Poly	593	
10,004	WRDC/MLLS	Blank	Poly	593	
10,005	WESTINGHOUSE	12:1	7052	954	
10,006	WRDC/MLLS	12:1	7052	954	
10,007	WRDC/MLLS	Blank	Poly	250	Mg-3Nd-2Mn-1Pr
10,008	WRDC/MLLS	Blank	Poly	250	Mg-3Nd-2Mn-1Pr
10,009	WRDC/MLLS	Blank	Poly	250	Mg-3Nd-2Mn-1Pr
10,010	WRDC/MLLS	Blank	C300/Poly	371	Al-8Fe-4Gd
10,011	WRDC/MLLS	Blank	C300/Poly	371	Al-8Fe-4Gd
10,012	WRDC/MLLS	Blank	C300/Poly	371	Al-8Fe-4Ce
10,013	WRDC/MLLS	Blank	C300/Poly	371	Al-4Ti-4Gd

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
10,014	WRDC/MLLS	8.2:1	C300/Poly	200	Mg-3Nd-2Mn-1Pr
10,015	WRDC/MLLS	12.2:1	C300/Poly	200	Mg-3Nd-2Mn-1Pr
10,016	GE/EVENDALE	Blank	Poly	927	Ti-25Al-5Nb-.4Er0
10,017	GE/EVENDALE	Blank	Poly	927	Ti-25Al-5Nb-.7Er0
10,018	GE/EVENDALE	Blank	Poly	927	Ti-25Al-5Nb-5Ta-.4Er
10,019	GE/EVENDALE	Blank	Poly	927	Ti-25Al-5Nb-5Ga0
10,020	GE/EVENDALE	Blank	Poly	927	Ti-25Al-5Nb-5Ta0
10,021	GE/EVENDALE	Blank	Poly	927	Ti-24Al-11Nb-.4Er0
10,022	WRDC/MLLS	12.2:1	C300/Poly	250	Mg-3Nd-2Mn-1Pr
10,023	WRDC/MLLS	20:1	C300/Poly	371	Al-8Fe-4Gd
10,024	WRDC/MLLS	20:1	C300/Poly	371	Al-8Fe-4Gd
10,025	WRDC/MLLS	20.1	C300/Poly	371	Al-8Fe-4Ce
10,026	WRDC/MLLS	20:1	C300/Poly	371	Al-4Ti-4Gd
10,027	WRDC/MLLS	Blank	Poly	816	Al-3Ti+Cu
10,028	GE/EVENDALE	8.4.1	7052	982	Ti-25Al-5Nd-.4Er
10,029	GE/EVENDALE	8.4:1	7052	982	Ti-25Al-2Nb-.7Er
10,030	GE/EVENDALE	8.4.1	7052	982	Ti-25Al-5Nb-5Ta-.4Er
10,031	GE/EVENDALE	8.4:1	7052	982	Ti-25Al-5Nb-5Ga
10,032	GE/EVENDALE	8.4:1	7052	982	Ti-25Al-5Nb-5Ta
10,033	GE/EVENDALE	8.4:1	7052	982	Ti-24Al-11Nb-.4Er
10,034	WRDC/MLLS	12:1	7052	1010	Al-3Ti-Cu
10,035	WRDC/MLLM	4.4:1		100	B-ER-Cu Oxide
10,036	WRDC/MLLS	Blank	Poly	927	Al-3Ti
10,037	WRDC/MLLS	12.4:1	7052	1067	Al-3Ti
10,038	WPDC/MLLS	Blank	Poly	250	Mg-3Nd-1Pr-2Mn

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,039	WRDC/MLLS	Blank	Poly	250	Mg-3Nd-1Pr-2Mn
10,040	WRDC/MLLS	Blank	Poly	250	Mg-3Nd-1Pr-2Mn
10,041	UES/WRDC/MLLS	12.4:1	7052	1150	Al-25Ti-8Ni
10,042	WRDC/MLLS	5.1:1	C300/Poly	250	Mg-3Nd-1Pr-2Mn
10,043	WRDC/MLLS	8:1	C300/Poly	250	Mg-3Nd-1Pr-2Mn
10,044	P&W/HARTFORD	8.8:1	7052	999	Ni-Al (A)
10,045	P&W/HARTFORD	8.8:1	7052	999	Ni-Al-(B)
10,046	P&W/HARTFORD	8.8:1	7052	999	Ni-Al (C)
10,047	P&W/HARTFORD	8.8:1	7052	999	Ni-Al (E)
10,048	P&W/HARTFORD	8.8:1	7052	999	Ni-Al (F)
10,049	P&W/HARTFORD	8.8:1	7052	999	Ni-Al(G)
10,050	P&W/HARTFORD	5:1	C300/Poly	200	Mg-3Nd-1Pr-2Mn
10,051	WRDC/MLLS	Blank	C300/Poly	1010	Ti-3Al
10,052	WRDC/MLLS	8.25:1	7052	1150	Al-25Ti-8Ni
10,053	WRDC/MLLS		Poly	1121	
10,054	UES/WRDC/MLLS	4.3:1	Bare	1500	Cu-Tube & Oxide
10,055	MARTIN-MARIETTA	4.7:1	7052	2372	Ti-45-48A/o-Al
10,056	MARTIN-MARIETTA	4.7:1	7052	2372	Ti-45-48A/o-Al
10,057	MARTIN-MARIETTA	4.7:1	7052	2372	Ti-45-48A/o-Al
10,058	MARTIN-MARIETTA	4.7:1	7052	2372	Ti-45-48A/o-Al
10,059	MARTIN-MARIETTA	4.7:1	7052	2372	Ti-45-48A/o-Al
10,060	MARTIN-MARIETTA	4.7:1	7052	2372	Ti-45-48A/o-Al
10,061	MARTIN-MARIETTA	4.3:1	7052	2372	Ti-45-48A/o-Al
10,062	MARTIN-MARIETTA	4.3:1	7052	2372	Ti-45-48A/o-Al
10,063	MARTIN-MARIETTA	4.3:1	7052	2372	Ti-45-48A/o-Al

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,064	MARTIN-MARIETTA	4.3:1	7052	2192	Ti-45-48A/o-Al
10,065	MARTIN-MARIETTA	4.3.1	7052	2192	Ti-45-48A/o-Al
10,066	MARTIN-MARIETTA	4.3:1	7052	2192	Ti-45-48A/o-Al
10,067	METCUT	Blank	C300/Poly	1000	
10,068	METCUT	Blank	C300/Poly	1000	
10,069	METCUT	Blank	C300/Poly	1000	
10,070	WRDC/MLLS	Blank	C300/Poly	482	Mg-3Nd-1Pr-2Mn
10,071	WRDC/MLLS	Blank	C300/Poly	482	Mg-12Al-4Zn-.5Mn
10,072	WRDC/MLLS	Blank	C300/Poly	482	Mg-9Li-3Al-2Si
10,073	WRDC/MLLS	Blank	C300/Poly	482	Mg-12Al-4Zn-.5Mn
10,074	WRDC/MLLS	8:1	C300/Poly	212	Mg-3Nd-1Pr-2Mn
10,075	WRDC/MLLS	8:1	C300/Poly	212	Mg-12Al-4Zn-.5Mn
10,076	WRDC/MLLS	8:1	7052	1700	Ti-10V-2Fe-3Al-Er_2-O_3
10,077	WRDC/MLLS	8:1	7052	1600	Ti-10V-2Fe-3Al-Er_2O_3
10,078	WRDC/MLLS	12:1	C300/Poly	302	Mg-12Al-4Zn-.5Mn
10,079	WRDC/MLLS	12:1	C300/Poly	302	Mg-9Li-3Al-2Si
10,080	UES	8:1	7052	1992	Al-25Ti-8Ni
10,081	WRDC/MLLS	8:1	7052	1400	Ti-10V-2Fe-3Al-Er_2O_3
10,082	WRDC/MLLS	8.1	7052	1300	Ti-10V-2Fe-3Al-Er_2O_3
10,083	GE/EVENDALE	Blank	C300/Poly	195	Ni-15.82Co-12.61Cr-4.98Mo-2.47Al-4.81Ti-3.13Ta-.2Hf-.015B-.03C-.03Zr

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
10,084	GE/EVENDALE	Blank	C300/Poly	1950	Ni-11.92Co-12.80Cr-5.06Mo-2.61Al-4.89Ti-1.63Nb-.2Hf-.015B-.03C-.03Zr
10,085	GE/EVENDALE	Blank	C300/Poly	1950	Ni-12Co-13Cr-3.5Hf-3.5W-3.1Al-2-2Ti-3.1Nb-.2Hf-.015B-.03C-.03Zr
10,086	GE/EVENDALE	Blank	C300/Poly	1950	Ni-17Co-15Cr-5Mo-2.5Al-4.7Ti-1.6Nb-.03B-.06C-.06Zr
10,087	GE/EVENDALE	Blank	C300/Poly	1950	Ni-11.78Co-12.66Cr-5.00Mo-2.11Al-4.83Ti-3.23Nb-0.2Hf-0.015B-0.03C-0.03Zr
10,088	GE/EVENDALE	Blank	C300/Poly	1950	Ni-8Co-13Cr-3.5Mo-3.5W-2.6Al-2.7Ti-3.8Nb-.2Hf-.015B-.03C-.03Zr
10,089	GE/EVENDALE	Blank	C300/Poly	1950	Ni-17Co-15Cr-5Mo-2.5Al-4.7Ti-3.1Ta-.2Hf-.03B-.06C-.06Zr
10,090	GE/EVENDALE	Blank	C300/Poly	1950	Ni-15.88Co-12.65Cr-5Mo-2.11Al-4.83Ti-3/23Nb-.2Hf-.15B-.03C-.03Zr
10,091	GE/EVENDALE	Blank	C300/Poly	1950	Ni-11.69Co-12.56Cr-4.97Mo-2.09Al-3.97Ti-4.81Nb-.2Hf-.015B-.03C-.03Zr
10,092	GE/EVENDALE	Blank	C300/Poly	1950	Ni-11.74Co-12.61Cr-4.99Mo-2.57Al-4.81Ti-3.13Ta-.2Hf-.015B-.03C-.03Zr
10,093	GE/EVENDALE	Blank	C300/Poly	1850	Ni-13Co-16Cr-5.5Mo-2.1Al-3.7Ti-1Nb-1.9Ta-.2Hf-.015B-.03C-.03Zr
10,094	GE/EVENDALE	7:1	7052	2000	Ni-15.82Co-12.61Cr-4.98Mo-2.57Al-4.81Ti-0.2Hf-0.015B-0.03C-0.03Cr

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^oC)	Composition
10,095	GE/EVENDALE	7:1	7052	2000	Ni-11.92Co-12.80Cr-5.06Mo-2.61Al-4.89Ti-1.63Nb-0.2Hf-0.015B-0.03C-0.03Zr
10,096	GE/EVENDALE	7:1	7052	2000	Ni-12Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Nb-0.2Hf-0.015B-0.03C-0.03Zr
10,097	GE/EVENDALE	7:1	7052	2000	Ni-17Co-15Cr-5Mo-2.5Al-4.7Ti-1.6Nb 0.03B-0.06C-0.06Zr
10,098	GE/EVENDALE	7:1	7052	2000	Ni-11.78Co-12.66Cr-5.00Mo-2.11Al-4.83Ti-3.23Nb-0.2Hf-0.015B-0.03C-0.03Zr
10,099	GE/EVENDALE	7:1	7052	2000	Ni-8Co-13Cr-3.5Mo-3.5W-2.6Al-2.7Ti-3.8Nb-0.2Hf-0.015B-0.03C-0.03Zr
10,100	GE/EVENDALE	7:1	7052	2000	Ni-17Co-15Cr-5.0Mo-2.5Al-4.7Ti-3.1Ta-0.2Hg-0.03B-0.06C-0.06Zr
10,101	GE/EVENDALE	7:1	7052	2000	Ni-15.88-12.65Cr-5.00Mo-2.11Al-4.83Ti-3.23Nb-0.2Hf-0.015B-0.03C-0.03Zr
10,102	GE/EVENDALE	7:1	7052	2000	Ni-11.69Co-12.56Cr-4.97Mo-2.09Al-3.97Ti-4.81Nb-0.2Hf-0.015B-0.03C-0.03Zr
10,103	GE/EVENDALE	7.1	7052	2000	Ni-11.74Co-12.61Cr-4.99Mo-2.57Al-4.81Ti-3.13Ta-0.2Hf-0.015B-0.03C-0.03Zr
10,104	GE/EVENDALE	7:1	7052	1900	Ni-13Co-16Cr-5.5Mo-2.1Al-3.7Ti-1.0Nb-1.9Ta-0.2Hf-0.015B-0.03C-0.03Zr
10,105	METCUT	12:1	C300/Poly	1000	
10,106	METCUT	12:1	C300/Poly	1000	

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
10,107	METCUT	12:1	C300/Poly	1000	
10,108	WRDC/MLLS	Blank	C300/Poly	1700	Al-3Ti
10,109	WRDC/MLLS	10:1	7052	1950	Al-3Ti
10,110	METCUT	Blank	C300/Poly	1200	Ti-8V-5Fe-1.3Al-(Granular)
10,111	METCUT	10:1	7052	1200	Ti-8V-5Fe-1.3Al (Granular)
10,112	METCUT	Blank	C300/Poly	800	Al-6Fe-6Co
10,113	METCUT	Blank	C300/Poly	800	Al-9Fe-7Ce
10,114	METCUT	Blank	C300/Poly	800	Al-9Fe-7Ce
10,115	METCUT	Blank	C300/Poly	750	Al-6Fe-6Co
10,116	METCUT	Blank	C300/Poly	750	Al-9Fe-6Ce
10,117	METCUT	Blank	C300/Poly	750	Al-9Fe-7Ce
10,118	METCUT	Blank	C300/Poly	700	Al-6Fe-6Co
10,119	METCUT	Blank	C300/Poly	700	Al-9Fe-7Ce
10,120	METCUT	Blank	C300/Poly	700	Al-9Fe-7Ce
10,121	UES	7.5:1	Bare	2600	Nb-3.5Si
10,122	GE/EVENDALE	Blank	C300/Poly	1960	Rene 95 + Ceramic
10,123	GE/EVENDALE	Blank	C300/Poly	1960	Rene 95 + Ceramic
10,124	GE/EVENDALE	Blank	C300/Poly	1960	Rene 95 + Ceramic
10,125	GE/EVENDALE	Blank	C300/Poly	1960	Rene 95 + Ceramic
10,126	GE/EVENDALE	Blank	C300/Poly	1960	Rene 95 + Ceramic
10,127	GE/EVENDALE	Blank	C300/Poly	1960	Rene 95 + Ceramic

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^oC)	Composition
10,128	GE/EVENDALE	Blank	C300/Poly	1960	Rene 95 + Ceramic
10,129	GE/EVENDALE	Blank	C300/Poly	1960	Rene 95 + Ceramic
10,130	GE/EVENDALE	Blank	C300/Poly	1960	Rene 95 + Ceramic
10,131	GE/EVENDALE	Blank	C300/Poly	1960	Rene 95 + Ceramic
10,132	GE/EVENDALE	Blank	C300/Poly	1960	Rene 95 + Ceramic
10,133	METCUT	11.9:1	C300/Poly	750	Rene 95+ Ceramic
10,134	METCUT	11.9:1	C300/Poly	750	Rene 95 + Ceramic
10,135	METCUT	11.9:1	C300/Poly	750	Rene 95 + Ceramic
10,137	METCUT	11.9:1	C300/Poly	750	Al-9Fe-7Ce
10,138	METCUT	11.9:1	C300/Poly	750	Al-9Fe-7Ce
10,139	METCUT	11.9.1	C300/Poly	750	Al-6Fe-6Co
10,140	METCUT	11.9:1	C300/Poly	750	Al-6Fe-7Ce
10,141	METCUT	11.9:1	C300/Poly	750	Al-9Fe-7Ce
10,142	GE/EVENDALE	Blank	C300/Poly	1850	Ni-18Co-16Cr-5Mo-3W-2.5Al-3Ti-3Nb-0.03B-0.05C-0.05Zr
10,143	GE/EVENDALE	Blank	C300/Poly	1850	Ni-13Co-16Cr-4Mo-4W-2.1Al-3.7Ti-0.7Nb 0.2Hf-0.015B-0.03C-0.03Zr
10,144	GE/EVENDALE	Blank	C300/Poly	1950	Ni-17Co-15Cr-5Mo-3.0W-2.5Al-4.7Ti-1.6Nb 0.03B-0.06C-0.06Zr
10,145	GE/EVENDALE	Blank	C300/Poly	1950	Ni-12Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Nb-0.2Hf-0.015B-0.03C-0.03Zr
10,146	GE/EVENDALE	Blank	C300/Poly	1950	Ni-12Co-13Cr-3.5Mo-3.5W 3.1Al-2.2Ti-3.1Nb-0.2Hf-0.015B-0.03C-0.03Zr

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,147	GE/EVENDALE	Blank	C300/Poly	1950	Ni-12Co-13Cr-3.5Mo-3.5W-2.6Al-2.7Ti-3.7Nb 0.2Hf-0.015B-0.03C-0.03Zr
10,148	GE/EVENDALE	Blank		1950	Ni-12Co-13Cr-3.5Mo-2.6Al 2.7Ti-3.7Nb-0.2B-0.015B-0.03C-0.03Zr
10,149	GE/EVENDALE	Blank	C300/Poly	2000	Ni-17Co-10Cr-5Mo-3.0Al-5.6Ti-1.9Nb-0.2Hf-0.03B-0.06C-0.06Zr
10,150	GE/EVENDALE	Blank	C300/Poly	2000	Ni-12Co-10Cr-3.5Mo-3.5W-3.9Al-2.8Ti-3.9Nb-0.2Hf-0.015B-0.03C-0.03Zr
10,151	GE/EVENDALE	Blank	C300/Poly	1900	Ni-18Co-16Cr-5Mo-3W-2.5Al-3Ti-3Nb-0.03B-0.05C-0.05Zr
10,152	GE/EVENDALE	Blank	C300/Poly	1900	Ni-13Co-16Cr-4Mo-4W-2.1Al-3.7Ti-0.7Nb-0.2Hf-0.015B-0.03C-0.03Zr-25ppm
10,153	GE/EVENDALE	7:1	7052	2000	Ni-17Co-15Cr-5Mo-3.0W-2.5Al-4.7Ti-1.6Nb-0.03B-0.06C-0.06Zr
10,154	GE/EVENDALE	7:1	7052	2000	Ni-12Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Nb-0.2Hf-0.015B-0.03C-0.03Zr
10,155	GE/EVENDALE	7:1	7052	2000	Ni-12Co-13Cr-3.5Mo-3.5W-3.1Al-2.2Ti-3.1Nb-0.2Hf-0.015B-0.03C-0.03Zr-100ppm
10,156	GE/EVENDALE	7:1	7052	2000	Ni-12Co-13Cr-3.5Mo-3.5W-2.6Al-2.7Ti-3.7Nb-0.2Hf-0.015B-0.03C-0.03Zr
10,157	GE/EVENDALE	7:1	7052	2000	Ni-12Co-13Cr-3.5Mo-2.6Al-2.7Ti-3.7Nb-0.2Hf-0.015B-0.03C-0.03Zr

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,158	GE/EVENDALE	7:1	7052	2050	Ni-17Co-10Cr-5Mo-3.0Al-5.6Ti-1.9Nb-0.2Hf-0.03B-0.06C-0.06Zr
10,159	GE/EVENDALE	7:1	7052	2050	Ni-12Co-10Cr-3.5Mo-3.5W-3.9Al-2.8Ti-3.9Nb-.2Hf-0.015B-0.03C-0.03Zr
10,160	UES/SWEENEY	4.4:1	Bare	2600	Nb-3.5Si
10,161	METCUT	Blank	C300/Poly	1100	
10,162	METCUT	Blank	C300/Poly	1100	
10,163	METCUT	Blank	C300/Poly	1100	
10,164	METCUT	Blank	8871	1160	
10,165	P&W/HARTFORD	9:1	7052	1830	Ni-Al
10,166	P&W/HARTFORD	9:1	7052	1830	Ni-Al
10,167	P&W/HARTFORD	9:1	7052	1830	Ni-Al
10,168	P&W/HARTFORD	9:1	7052	1830	Ni-Al
10,169	P&W/HARTFORD	9:1	7052	1830	Ni-Al
10,170	P&W/HARTFORD	9:1	7052	1830	Ni-Al
10,171	P&W/HARTFORD	9.1	7052	1830	Ni-Al
10,172	P&W/HARTFORD	9:1	7052	1830	Ni-Al
10,173	WRDC/MLLS	12:1	C300/Poly	1000	Al-8Fe-4Ce/ /20V/o-SiCp
10,174	WRDC/MLLS	12:1	C300/Poly	1000-2 h 1100-1 h	Al-8Fe-2Mo-20V/o-Co
10,175	WRDC/MLLS	Blank	C300/Poly	1650	Ti
10,176	WRDC/MLLS	Blank	C300/Poly	1650	Ti
10,177	GE/EVENDALE	7.5:1	7052	2000	Rene 95 + Ceramic
10,178	WRDC/MLLS	10:1	C300/Poly	1100	Al-8Fe-4Ce-20Si-Cr
10,179	WRDC/MLLS	10:1	C300/Poly	1050	Al-8Fe-2Mo-20V/o-Co

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,180	WRDC/MLLS	8:1	7052	1650	Ti
10,181	WRDC/MLLS	8:1	7052	1650	Ti
10,182	GE/EVENDALE	7.5:1	7052	2000	Rene 95 + Ceramic
10,183	GE/EVENDALE	7.5:1	7052	2000	Rene 95 + Ceramic
10,184	GE/EVENDALE	7.5:1	7052	2000	Rene 95 + Ceramic
10,185	GE/EVENDALE	4.4:1	7052	2000	Rene 95 + Ceramic
10,186	GE/EVENDALE	4.4:1	7052	2000	Rene 95 + Ceramic
10,187	GE/EVENDALE	10:1	7052	2000	Rene 95 + Ceramic
10,188	GE/EVENDALE	10:1	7052	2000	Rene 95 + Ceramic
10,189	GE/EVENDALE	7.4:1	7052	2000	Rene 95 + Ceramic
10,190	GE/EVENDALE	7.4:1	7052	2000	Rene 95 + Ceramic
10.191	P&W/HARTFORD	8.73:1	7052	1830	Ni-Al
10,192	P&W/HARTFORD	8.73:1	7052	1830	Ni-Al
10,193	METCUT	12:1	C300/Poly	1150	Al-Ti
10,194	METCUT	12:1	C300/Poly	1150	Al-Ti
10,195	METCUT	12:1	C300/Poly	1150	Al-Ti
10,196	METCUT	Blank	C300/Poly	1200	Ti-8V-5Fe-1.3Al
10,197	METCUT	10:1	7052	1200	Ti-8V-5Fe-1.3Al
10,198	WESTINGHOUSE	12.1	7052	982	Ti-6Al-4V
10,199	WRDC/MLLS	3:1	7052	760	Ti-10V-2Fe-3Al-1.5Er
10,200	WRDC/MLLS	7.3:1	7052	760	Ti-10V-2Fe-3Al-1.5Er
10,201	WRDC/MLLS	7.3:1	7052	871	Ti-10V-2Fe-3Al-1.5Er
10,202	WRDC/MLLS	7.3:1	7052	871	Ti-10V-2Fe-3Al-1.5Er
10,203	WRDC/MLLS	Blank	C300/Poly	1093	Ti_3Al-7Fe

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,204	GE/EVENDALE	15.9:1	7052	1000	Ti-51Al-2Nb
10,205	WRDC/MLLS	11.9:1	7052	1093	Ti_3Al-7Fe
10,206	WRDC/MLLS	Blank	C300/Poly	1093	Ti_3Al-15V
10,207	WRDC/MLLS	12:1	7052	1093	Ti_3Al-15V
10,208	WRDC/MLLS	Blank	C300/Poly	954	IMI-829 + C
10,209	WRDC/MLLS	Blank	C300/Poly	954	IMI-829 + Re
10,210	McDONNEL DOUGLAS	11.9:6	7052	1343	Ti-Al (Y)
10,211	McDONNEL DOUGLAS	11.9:6	7052	1343	Ti-Al (Y)
10,212	McDONNEL DOUGLAS	11.9:6	7052	1343	Ti-Al (Y)
10,213	WRDC/MLLS	11.9:1	7052	954	IMI-829 + C
10,214	WRDC/MLLS	11.9:1	7052	954	IMI-829-Re
10,215	WRDC/MLLS	Blank	C300/Poly	1093	Ti_3Al-6Cu
10,216	WRDC/MLLS	Blank	C300/Poly	982	Ti-Al-Nb-Mo-V-Re
10,217	WRDC/MLLS	11.9.1	7052	1093	Ti_3Al-6Cu
10,218	WRDC/MLLS	Blank	C300/Poly	250	Mg-9Li-3Al-2Si
10,219	WRDC/MLLS	Blank	C300/Poly	250	Mg-12Al-4Zn-.5Mn
10,220	WRDC/MLLS	Blank	C300/Poly	250	Mg-3Nd-2Mn-1Pr
10,221	WRDC/MLLS	Blank	C300/Poly	250	Mg-12Al-4Zn-.5Mn
10,222	WRDC/MLLS	Blank	C300/Poly	250	Mg-3Nd-2Mn-1Pr
10,223	WRDC/MLLS	Blank	C300/Poly	250	Mg-9Li-3Al-2Si
10,224	WRDC/MLLS	12:1	7052	982	Ti_3Al-Nb-Mo-V-Re

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
10,225	WESTINGHOUSE	4:1	Bare	2204	W-HfC
10,226	P&W/FL	13.54:1	7052	1232	Ti-Al Gamma
10,227	P&W/FL	16.34:1	7052	1232	Ti-Al Gamma
10,228	P&W/FL	Rect.	7052	1232	Ti-Al Gamma
10,229	P&W/FL	Rect.	7052	1232	Ti-Al Gamma
10,230	P&W/FL	13.54:1	7052	1204	Ti-Al Gamma
10,231	P&W/FL	16.34:1	7052	1204	Ti-Gamma
10,232	P&W/FL	Rect.	7052	1204	Ti-Gamma
10,233	P&W/FL	Rect.	7052	1204	Ti-Gamma
10,234	GE/EVENDALE	Blank	C300/Poly	1010	Ni-13Co-16Cr-5.5Mo-1.6Al-3.7Ti-3.6Nb-0.2Hf-0.015B-0.03C-0.03Zr
10,235	GE/EVENDALE	Blank	C300/Poly	1121	Ni-15Co-10Cr-3Mo-5.5Al-2.2Ti-1.4Nb-2.7Ta-.03B-.05C-.05Zr
10,236	P&W/HARTFORD	9:1	7052	999	Ni-Al
10,237	P&W/HARTFORD	9:1	7052	999	Ni-Al
10,238	P&W/HARTFORD	9:1	7052	999	Ni-Al
10,239	GE/EVENDALE	7:1	7052	1038	Ni-13Co-16Cr-5.5Mo-1.6Al-3.7Ti-3.6Nb-0.2Hf-0.015B-0.03C-0.03Zr
10,240	GE/EVENDALE	7:1	7052	1149	Ni-15Co-10Cr-3Mo-5.5Al-2.2Ti-1.4Nb-2.7Ta-0.03B-0.05C 0.05Zr
10,241	P&W/HARTFORD	9:1	7052	1149	Ni-Al
10,242	WRDC/MLLS	Blank	C300/Poly	1093	Ti_3Al-6Cr

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
10,243	WRDC/MLLS	12:1	7052	1093	Ti_3Al-6Cr
10,244	UES	8.3:1	7052	1100	Al-37Ti-11.7Ni
10,245	UES	8.3:1	7052	1100	Al-37Ti-11.7Ni
10,246	P&W/FL	4.4:1	7052	982	Ti-45Nb-5Al
10,247	P&W/FL	4.4:1	7052	982	Ti-40Nb-15Al
10,248	P&W/FL	4.4:1	7052	982	Ti-45Nb-14Al
10,249	WRDC/MLLS	Blank	C300/Poly	1093	Ti-15V-3Al-3Cr-3Sn
10,250	WRDC/MLLS	12.5:1	C300/Poly	225	Mg-9Li-3Al-2Si
10,251	WRDC/MLLS	12.5:1	C300/Poly	225	Mg-12Al-4Zn-.5Mn
10,252	WRDC/MLLS	12.5:1	C300/Poly	225	Mg-3Nd-2Mn-1Pr
10,253	WRDC/MLLS	12.5:1	C300/Poly	350	Mg-12Al-4Zn-.5Mn
10,254	WRDC/MLLS	12.5:1	C300/Poly	350	Mg-3Nd-2Mn-1Pr
10,255	WRDC/MLLS	12.5:1	C300/Poly	350	Mg-9Li-3Al-2Si
10,256	WRDC/MLLS	10:1	7052	760	Ti-15V-3Al-3Cr-3Sn
10,257	(W) BASIC	3.73:1	C300/Poly	None	CP-Al
10,258	(W) BASIC	6:1	C300/Poly	None	CP-Al
10,259	(W) BASIC	9:1	7052	1038	410 S. S.
10,260	GE/EVENDALE	Blank	C300/Poly	838	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.2Si-1Y
10,261	GE/EVENDALE	Blank	C300/Poly	838	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.2Si-1Y
10,262	GE/EVENDALE	Blank	C300/Poly	838	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.2Si-1Y
10,263	GE/EVENDALE	Blank	C300/Poly	838	Ti-6.4Al-3Zr-3.2Sn-2.5Hf-1Nb-.3Ru-.33Ge-3Er-.15Si

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,264	GE/EVENDALE	Blank	C300/Poly	838	Ti-6.4Al-3Zr-3.2Sn-2.5Hf-1Nb-.3Ru-.33Ge-3Er-.15Si
10,265	GE/EVENDALE	Blank	C300/Poly	838	Ti-6.4Al-3Zr-3.2Sn-2.5Hf-1Nb-.3Ru-.33Ge-3Er-.15Si
10,266	GE/EVENDALE	Blank	C300/Poly	1149	Ti-14.1Al-19.5Nb-3.2V-2Mo
10,267	GE/EVENDALE	Blank	C300/Poly	1149	Ti-14.1Al-19.5Nb-3.2V-2Mo
10,268	GE/EVENDALE	Blank	C300/Poly	1149	Ti-14.1Al-19.5Nb-3.2V-2Mo
10,269	GE/EVENDALE	Blank	C300/Poly	1316	Ti-32.2Al-1.3V
10,270	GE/EVENDALE	Blank	C300/Poly	1316	Ti-32.2Al-1.3V
10,271	GE/EVENDALE	8.8:1	7052	1199	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.2Si-1Y(W%)
10,272	GE/EVENDALE	8.8:1	7052	1199	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.2Si-1Y(W%)
10,273	GE/EVENDALE	8.8:1	7052	1199	Ti-6.4Al-3Zr-3.2Sn-2.5Hf-1Nb-.3Ru-.33Ge-3Er-.15Si(W%)
10,274	GE/EVENDALE	8.8:1	7052	1199	Ti-6.4Al-3Zr-3.2Sn-2.5Hf-1Nb-.3Ru-.33Ge-3Er-.15Si(W%)
10,275	GE/EVENDALE	8.8:1	7052	1149	Ti-14.1Al-19.5Nb-3.2V-2Mo(W%)
10,276	GE/EVENDALE	8.8:1	7052	1149	Ti-14.1Al-19.5Nb-3.2V-2Mo(W%)
10,277	GE/EVENDALE	8.8:1	7052	1316	Ti-32.2Al-1.3V(W%)
10,278	GE/EVENDALE	8.8:1	7052	1316	Ti-32.2Al-1.3V(W%)
10,279	GE/EVENDALE	8.8:1	7052	1149	Ti-14.1Al-19.5Nb-3.2V-2Mo(W%)

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
10,280	GE/EVENDALE	8.8:1	7052	1199	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.2Si-1Y(W%)
10,281	GE/EVENDALE	8.8:1	7052	1199	Ti-6.4Al-3Zr-3.2Sn-2.5Hf-1Nb-.3Ru-.33Ge-3Er-.15Si(W%)
10,282	GE/EVENDALE	Blank	C300/Poly	1121	Ni-15.0Co-8.0Cr-3.0Mo 5.5Al-2.9Ti-2.7Ta-1.0V-0.03B-0.05C-0.05Zr
10,283	GE/EVENDALE	Blank	C300/Poly	1121	Ni-17.0Co-8.0Cr-4.0Mo-5.5Al-2.9Ti-2.7Ta-10V-0.03B-0.05C-0.05Zr
10,284	GE/EVENDALE	Blank	C300/Poly	1121	Ni-15.0Co-10.0Cr-3.0Mo-4.5Al-4.0Ti-1.4Nb-2.7Ta-1.0V-0.03B-0.05C-0.06Zr
10,285	GE/EVENDALE	Blank	C300/Poly	1093	Ni-18.0Co-12.0Cr-4.0Mo-4.0Mo-4.0Ti-2.0Nb-0.03B-0.03C-0.03Zr
10,286	GE/EVENDALE	Blank	C300/Poly	1066	Ni-17.0Co-15.0Cr-5.0Mo-2.5Al-4.7Ti-0.8Nb-1.5Ta-0.03B-0.06C-0.06Zr
10,287	GE/EVENDALE	Blank	C300/Poly	1066	Ni-14.0Co-13.0Cr-4.5Mo-3.1Al-2.2Ti-3.1Nb-1.4Ta-0.2Hf-0.015B-0.03C-0.03Zr
10,288	GE/EVENDALE	Blank	C300/Poly	1066	Ni-17.98Co-10.88Cr-6.69Mo-2.59Al-4.84Ti-1.62Nb-0.2Hf-0.015B-0.03C-0.03Zr
10,289	GE/EVENDALE	Blank	C300/Poly	1066	Ni-18.11Co-10.96Cr-6.74Mo-3.55Al-3.20Ti-1.63Nb-0.2Hf-0.015B-0.03C-0.03Zr
10,290	GE/EVENDALE	Blank	C300/Poly	1010	Ni-13.0Co-16.0Cr-3.0Mo-1.6Al-3.7Ti-3.6Nb-0.2Hf-0.015B-0.03C-0.03Zr

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
10,291	GE/EVENDALE	Blank	C300/Poly	1010	Ni-18.0Co-14.0Cr-5.0Mo-1.5W-2.5Al-3.0Ti-3.0Nb-0.03B-0.05C-0.05Zr
10,292	GE/EVENDALE	Blank	C300/Poly	1010	Ni-16.0Co-16.0Cr-6.5Mo-2.1Al-3.7Ti-1.0Nb-1.9Ta-0.2Hf-0.015B-0.03C-0.03Zr
10,293	GE/EVENDALE	Blank	C300/Poly	1010	Ni-16.0Co-16.0Cr-6.5Mo-3.0Al-2.1Ti-1.0Nb-1.9Ta-0.2Hf-0.015B-0.03C-0.03Zr
10,294	GE/EVENDALE	7.26:1	7052	1038	Ni-13.0Co-16.0Cr-3.0Mo-1.6Al-3.7Ti-3.6Nb-0.2Hf-0.015B-0.03C-0.03Zr
10,295	GE/EVENDALE	7.6:1	7052	1038	Ni-18.0Co-14.0Cr-5.0Mo-1.5W-2.5Al-3.0Ti-3.0Nb-0.03B-0.05C-0.05Zr
10,296	GE/EVENDALE	7.6:1	7052	1038	Ni-16.0Co-16.0Cr-6.5Mo-2.1Al-3.7Ti-1.0Nb-1.9Ta-0.2Hf-0.015B-0.03C-0.03Zr
10,297	GE/EVENDALE	7.26:1	7052	1038	Ni-16.0Co-16.0Cr-6.5Mo-2.1Al-3.7Ti-1.0Nb-1.9Ta-0.2Hf-0.015B-0.03C-0.03Zr
10,298	GE/EVENDALE	7.2:1	2000	1093	Ni-17.0Co-15.0Cr-2.5Al-4.7Ti-0.8Nb-1.5Ta-0.03B-0.06C-0.06Zr
10,299	GE/EVENDALE	7.2:1	7052	1193	Ni-14.0Co-13.0Cr-4.5Mo-3.1Al-2.2Ti-3.1Nb-1.4Ta-0.2Hf-0.015B-0.03C-0.03Zr
10,300	GE/EVENDALE	7.2:1	7052	1093	Ni-17.98Co-10.88Cr-6.69Mo-2.59Al-4.84Ti-1.6Nb-0.2Hf-0.015B-0.03C-0.03Zr
10,301	GE/EVENDALE	7.2:1	7052	1093	Ni-18.11Co-10.96Cr-6.74Mo-3.55Al-3.20Ti-1.63Nb-0.2Hf-0.015B-0.03C-0.03Zr

TABLE III-1: <u>Billets Processed by Extrusion</u>--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,302	GE/EVENDALE	7.2:1	7052	1121	Ni-18.0Co-12.0Cr-4.0Mo-4.0Al-4.0Ti-2.0Nb-0.03B-0.03C-0.03Zr
10,303	GE/EVENDALE	7.2:1	7052	1149	Ni-15.0Co-8.0Cr-3.0Mo-5.5Al-2.9Ti-2.7Ta-1.0V 0.03B-0.05C-0.05Zr
10,304	GE/EVENDALE	7.2:1	7052	1149	Ni-17.0Co-8.0Cr-4.0Mo-5.5Al-2.9Ti-2.7Ta-1.0V-0.03B-0.05C-0.05Zr
10,305	GE/EVENDALE	7.2:1	7052	1149	Ni-15.0Co-10.0Cr-3.0Mo-4.5Al-4.0Ti-1.4Nb-2.[illegible]Ta-V-0.03B-0.05C-0.06Zr
10,306	METCUT	Blank	C300/Poly	649	Ti-1Al-8V-5Fe-1Er
10,307	METCUT	Blank	C300/Poly	649	Ti-1Al-8V-5Fe
10,308	METCUT	Blank	C300/Poly	649	Ti-1Al-BV-5Fe-1B
10,309	METCUT	10:1	7052	649	Ti-1Al-8V-5Fe-1Er
10,310	[illegible]CUT	10:1	7052	649	Ti-1Al-8V-5Fe
10,311	MET[illegible]	10:1	7052	649	Ti-1Al-8V-5Fe-1B
10,312	METCUT	10.5:1	7052	649	Ti-1Al-8V-5Fe-1Er
10,313	WRDC/MLLS	Blank	C300/Poly	843	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.2S[illegible]-1Y
10,314	WRDC/MLLS	Blank	C300/Poly	843	Ti-8A[illegible]-2.8Sn-5.4Hf-3.6Ta-.2Si-1Y
10,315	WESTINGHOUSE	10:1	7052	1093	410 SS
10,316	WRDC/MLLS	10:1	7052	843	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.2Si-1Y
10,317	WRDC/MLLS	8:1	7052	843-1 h 899-1 h	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.2Si-1Y

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^oC)	Composition
10,318	WRDC/MLLS	8:1	7052	899	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.2Si-1Y
10,319	CRUCIBLE	4.2:1	7052	1121	Co-28Cr-6Mo
10,320	WRDC/MLLS	10.2:1	7052	927	Ti-6-6-2
10,321	MARTIN-MARIETTA	3.5:1	7052	1200	Ti-45Al-2V-TiB_2
10,322	MARTIN-MARIETTA	3.5:1	7052	1200	Ti-45Al-30%TiB_2
10,323	MARTIN-MARIETTA	3.5:1	7052	1100	Ti-6Al-4V-TiB_2
10,324	MARTIN-MARIETTA	3.5:1	7052	1200	Ti-45Al-TiB_2
10,325	MARTIN-MARIETTA	3.5:1	7052	1200	Ti-45Al-TiB_2
10,326	MARTIN-MARIETTA	3.5:1	7052	1200	Ti-45Al-2V-TiB_2
10,327	MARTIN-MARIETTA	3.5:1	7052	1200	Ti-45Al-2V-TiB_2
10,328	P&W	7.3:1	7052	1288	Ti32.1Al-4.8Nb-1.1Ta
10,329	P&W	10:1	7052	1288	Ti-32.1Al-4.8Nb-1.1Ta
10,330	P&W	12:1	7052	1288	Ti-32.1Al-4.8Nb-1.1Ta
10,331	P&W	12:1	7052	1288	Ti-32.1Al-4.8Nb-1.1Ta
10,332	P&W	15:1	7052	1288	Ti-33.4Al-4.9Nb-1.2Ta
10,333	P&W	6.2:1	7052	1038	Ti-32.1Al-4.8Nb-1.1Ta
10,334	P&W	6.2:1	7052	1038	Ti-32.1Al-4.8Nb-1.1Ta
10,335	P&W	7.3:1	7052	1038	Ti-32.1Al-4.8Nb-1.1Ta
10,336	P&W	10:1	7052	1038	Ti-32.1Al-4.8Nb-1.1Ta
10,337	P&W	6:1	7052	1010	Ti-32.1Al-4.8Nb-1.1Ta
10,338	P&W	6:1	7052	1010	Ti-32.1Al-4.8Nb-1.1Ta
10,339	MARTIN-MARIETTA	27:1	C300/Poly	470	5356Al-TiB_2
10,340	P&W	6:1	7052	982	Ti-32.1Al-4.8Nb-1.1Ta

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,341	P&W	6:1	7052	982	Ti-32.1Al-4.8Nb-1.1Ta
10,342	MARTIN-MARIETTA	3.5:1	7052	1200	Ti-45Al-2V-TiB_2
10,343	P&W/FL	6:1	7052	1038	Ti-34.8Al-4.7Ta
10,344	P&W/FL	9.7:1	7052	1038	Ti-34.8Al-4.7Ta
10,345	P&W/FL	9.7:1	7052	1066	Ti-34.8Al-4.7Ta
10,346	P&W/FL	13:1	7052	1066	Ti-34.8Al-4.7Ta
10,347	P&W/FL	Blank	C300/Poly	1066	Ti-33.5Al-.9Ta
10,348	GE/EVENDALE	8:1	7052	1038	Cast-Ti-25Al-11Nb
10,349	GE/EVENDALE	12:1	7052	1038	Cast-Ti-25Al-11Nb
10,350	GE/EVENDALE	12:1	7052	1038	Cast-Ti-25Al-11Nb
10,351	GE/EVENDALE	20:1	7052	1038	Cast-Ti-25Al-11Nb
10,352	P&W/FL	9.9:1	7052	1066	Ti-33.5Al-9Ta
10,353	P&W/FL	9.9:1	7052	1066	Ti-33.5Al.9Ta
10,354	P&W/FL	9.9:1	7052	1066	Ti-52Al-10Ni
10,355	P&W/FL	9.9:1	7052	1066	Ti-34Al-11.2Nb
10,356	P&W/FL	10:1	7052	1010	Ti-34Al-6Nb-2TiB_2 + 20V/oNb
10,357	P&W/FL	10:1	7052	1010	Ti-34Al-6Nb-2TiB_2 + 20V/oNb
10,358	P&W/FL	10:1	7052	982	Ti-34Al-6Nb-3TiB_2 + 20V/oNb
10,359	P&W/FL	10:1	7052	982	Ti-34Al-6Nb-3TiB_2 + 20V/oNb
10,360	P&W/FL	Blank	C300/Poly	1038	Ti-34Al-.9Nb
10,361	WRDC/MLLS	Blank	C300/Poly	816	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.02S-1Y
10,362	WRDC/MLLS	Blank	C300/Poly	816	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.02S-1Y

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^oC)	Composition
10,363	GE/EVENDALE	16.7:1	7052	1200	Ti-Al (Gamma)
10,364	GE/EVENDALE	16.7:1	7052	1200	Ti-Al (Gamma)
10,365	MARTIN-MARIETTA	10:1	7052	1250	Ti-48Al-2V-7.5W/o TiB_2
10,366	MARTIN-MARIETTA	10:1	7052	1250	Ti-48Al-2V-7.5W/o-TiB_2
10,367	WRDC/MLLS	Blank	C300/Poly	1093	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.02S-1Y
10,368	WRDC/MLLS	Blank	C300/Poly	1093	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.02S-1Y
10,369	WRDC/MLLS	Blank	C300/Poly	1093	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.02S-1Y
10,370	P&W/FL	8:1	7052	1038	Ti-34.4Al-8.9Nb
10,371	P&W/FL	8:1	7052	1038	Ti-34.4Al-8.9Nb
10,372	WRDC/MLLS	8:1	7052	816	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.02S-1Y
10,373	WRDC/MLLS	8:1	7052	816	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.02S-1Y
10,374	WRDC/MLLS	8:1	7052	1093	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.02S-1Y
10,375	WRDC/MLLS	8:1	7052	1093	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.02S-1Y
10,376	WRDC/MLLS	8:1	7052	1093	Ti-8Al-2.8Sn-5.4Hf-3.6Ta-.02S-1Y
10,377	MARTIN-MARIETTA	27:1	Poly	849	XD-CU Powder
10,378	MARTIN-MARIETTA	10:1	7052	1250	
10,379	MARTIN-MARIETTA	10:1	7052	1250	
10,380	MARTIN-MARIETTA	10:1	7052	1050	Ti-6Al-4V
10,382	MARTIN-MARIETTA	10:1	7052	1050	Ti-6Al-4V-B

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,383	P&W/FL	9.5:1	7052	954	Ti-34Al-5Nb-1Ta
10,384	P&W/FL	9.5:1	7052	927	Ti-34Al-5Nb-1Ta
10,385	P&W/FL	9.5:1	7052	927	Ti-34Al-5Nb-1Ta
10,386	P&W/FL	9:1	7052	999	VIM (Ni-Al)
10,387	P&W/FL	9:1	7052	999	VIM (Ni-Al)
10,388	P&W/FL	9:1	7052	999	VIM (Ni-Al)
10,389	P&W/FL	9:1	7052	999	VIM (Ni-Al)
10,390	P&W/FL	9:1	7052	999	VIM (Ni-Al)
10,391	P&W/FL	9:1	7052	999	VIM (Ni-Al)
10,392	MARTIN-MARIETTA	3.2:1	7052	1200	Ti-45Al-7TiB_2
10,393	MARTIN-MARIETTA	9.5:1	7052	1250	Ti-48Al-2V/TiB_2
10,394	MARTIN-MARIETTA	9.5:1	7052	1250	Ti-48Al-2V/TiB_2
10,395	GE/EVENDALE	Blank	C300/Poly	1093	Ti-25Al-10Nb-3V-1Mo
10,396	GE/EVENDALE	Blank	C300/Poly	1093	A/o-Ti-25Al-10Nb-3V-1Mo
10,397	GE/EVENDALE	Blank	C300/Poly	1080	A/o-Ti-11.7Al-1.6Zr-1.4Sn-.7Hf-.5Nb-.13Ru-.2Si-.25Ge- 1.1Er
10,398	GE/EVENDALE	Blank	C300/Poly	1080	A/o-Ti-11.7Al-1.6Zr-1.4Sn-.7Hf-.5Nb-.13Ru-.2Si-.25Ge- 1.1Er
10,399	GE/EVENDALE	Blank	C300/Poly	838	A/o-Ti-11.7Al-1.6Zr-1.4Sn-.7Hf-.5Nb-.13Ru-.2Si-.25Ge- 1.1Er
10,400	GE/EVENDALE	Blank	C300/Poly	838	A/o-11.7Al-1.6Zr-1.4Sn-.7Hf-.5Nb-.13Ru-.2Si-.25Ge-1.1Er

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^oC)	Composition
10,402	GE/EVENDALE	Blank	C300/Poly	838	A/o-Ti-14.5Al-1.1Sn-1.3Hf-.9Ta-.25Si-.6Y
10,403	GE/EVENDALE	Blank	C300/Poly	838	A/o-Ti-14.5Al-1.1Sn-1.3Hf-.9Ta-.25Si-.6Y
10,404	GE/EVENDALE	Blank	C300/Poly	838	A/o-Ti-14.5Al-1.1Sn-1.3Hf-.9Ta-.25Si-.6Y
10,405	GE/EVENDALE	9:1	7052	1093	A/o-Ti-25Al-10Nb-3V-1Mo
10,406	GE/EVENDALE	9:1	7052	1093	A/o-Ti-25Al-10Nb-3V-1Mo
10,407	GE/EVENDALE	9:1	7052	1199	A/o-Ti-11.7Al-1.6Zr-1.4Sn-.7Hf-.5Nb-.13Ru-.2Si-.25Ge-1.1Er
10,408	GE/EVENDALE	9:1	7052	1199	Ti-11.7Al-1.6Zr-1.4Sn-.7Hf-.5Nb-.13Ru-.2Si-.25Ge-1.1Er
10,409	GE/EVENDALE	9:1	7052	1199	Ti-11.7Al-1.6Zr-1.4Sn-.7Hf-.5Nb-.13Ru-.2Si-.25Ge-1.1Er
10,410	GE/EVENDALE	9.1	7052	1199	Ti-11.7Al-1.6Zr-1.4Sn-.7Hf-.5Nb-.13Ru-.2Si-.25Ge-1.1Er
10,411	GE/EVENDALE	18:1	7052	1199	Ti-14.5Al-1.1Sn-1.1Hf-.9Ta-.25Si-.6Y
10,412	GE/EVENDALE	18:1	7052	1199	Ti-14.5Al-1.1Sn-1.3Hf-.9Ta-.25Si-.6Y
10,413	GE/EVENDALE	9:1	7052	1199	Ti-14.5Al-1.1Sn-1.3Hf-.9Ta-.25Si-.6Y
10,414	GE/EVENDALE	9.1	7052	1199	Ti-14.5Al-1.1Sn-1.3Hf-.9Ta-.25Si-.6Y
10,415	GE/EVENDALE	11.9:1	7052	1038	Ti-14.2Al-16Nb-w/o
10,416	GE/EVENDALE	11.9.1	7052	1038	Ti-14.2Al-12Nb-4.1Mo
10,417	GE/EVENDALE	11.9:1	7052	1038	Ti-13.7Al-19.3Nb-4.0Mo

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
10,418	GE/EVENDALE	11.9:1	7052	1038	Ti-13.2Al-18.6Nb-7 2Ta
10,419	GE/EVENDALE	22.3:1	7052	1038	Ti-13.5Al-11.4Nb-7.4Ta 3.9Mo-2.1V
10,420	LOS ALAMOS	Blank	7052	1200	Ti-37.7Al-8Nb
10,421	GE/EVENDALE	Blank	C300/Poly	1010	Ni-32.53Fe-10.48Al
10,422	P&W/HARTFORD	9:1	7052	999	(VIM) Ni-Al
10,423	GE/EVENDALE	Blank	C300/Poly	1010	Ni-22.61Fe-15.02Al
10,424	P&W/HARTFORD	9:1	7052	999	(VIM) Ni-Al
10,425	GE/EVENDALE	Blank	C300/Poly	1010	Ni-11.06Fe-13.26Al
10,426	P&W/HARTFORD	9:1	7052	999	(VIM) Ni-Al
10,427	GE/EVENDALE	Blank	7052	1038	Ni-32.53Fe-10.48Al
10,428	GE/EVENDALE	7:1	7052	1038	Ni-22.61Fe-15.02Al
10,429	GE/EVENDALE	7:1	7052	1038	Ni-11.06Fe-13.26Al
10,430	P&W/HARTFORD	9:1	7052	999	P/M (Ni-Al)
10,431	McDONNELL-DOUGLAS	18.5:1	7052	1343	Ti-Al
10,432	McDONNELL-DOUGLAS	18.5:1	7052	1343	Ti-Al
10,433	McDONNELL-DOUGLAS	18.5:1	7052	1343	Ti-Al
10,434	WESTINGHOUSE	"P" Die Design	C300/Poly	419	(2024) CP-Ti785
10,435	WESTINGHOUSE	"P" Die Design	C300/Poly	419	(2024) CP-Ti785
10,436	WESTINGHOUSE	8:1	C300/Poly	419	2024 Al
10,437	WESTINGHOUSE	8:1	C300/Poly	419	2024 Al
10,438	WRDC/MLLS	8:1	7052	900	Ti-Al (Gamma)
10,439	WESTINGHOUSE	8:1	C300/Poly	419	1100 Al
10,440	WESTINGHOUSE	8:1	C300/Poly	419	2024 Al (New Tooling)

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
10,441	GE/EVENDALE	23:1	7052	1038	Ti-13.5Al-11.4Nb-7.4Ta-3.9Mo-2.1V
10,442	GE/EVENDALE	23:1	7052	1038	Ti-13.5Al-11.4Nb-7.4Ta-3.9Mo-2.1V
10,443	GE/EVENDALE	23:1	7052	1038	Ti-13.2Al-14.9Nb-3.8Mo-7.2Ta
10,444	GE/EVENDALE	23:1	7052	1038	Ti-13.2Al-14.9Nb-3.8Mo-7.2Ta
10,445	GE/EVENDALE	23:1	7052	1038	Ti-13.4Al-11.3Nb-7.4Ta-3.9Mo-2.1Cr
10,446	GE/EVENDALE	23:1	7052	1038	Ti-13.4Al-11.3Nb-7.4Ta-3.9Mo-2.1Cr
10,447	GE/EVENDALE	23:1	7052	1038	Ti-13.4Al-11.3Nb-7.4Ta-3.9Mo-2.1Cr-.1C
10,448	MLLS	10.3:1	7052	982	Ti-25-10-3-1
10,449	MLLS	3:1	7052	1200	Ti-25-10-3-1
10,450	SPS TECHNOLOGIES	2.38:1	7052	1160	
10,451	GE/EVENDALE	10:1	7052	1155	Ti-35.73Al-11.83Nb
10,452	UES	"P"	C300/Poly	399	1100Al
10,453	UES/WESTINGHOUSE	"P"	C300/Poly	399	1100Al
10,454	UES/WESTINGHOUSE	"P"	C300/Poly	419	Al-Li
10,455	UES/WESTINGHOUSE	"P"	C300/Poly	419	Al-Li
10,456	SPS TECHNOLOGIES	4.25:1	7052	1093	Co-27Ni-19Cr-1.4Al-9Fe-.7Mo-3Ti
10,457	SPS TECHNOLOGIES	4.25:1	7052	1093	Co-27Ni-19Cr-1.4Al-9Fe-.7Mo-3Ti
10,458	SPS TECHNOLOGIES	4.25:1	7052	1093	Co-27Ni-19Cr-1.4Al-9Fe-.7Mo-3Ti
10,459	SPS TECHNOLOGIES	4.25:1	7052	1093	Co-27Ni-19Cr-1.4Al-9Fe-.7Mo-3Ti

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,460	SPS TECHNOLOGIES	4.25:1	7052	1093	Co-27Ni-19Cr-1.4Al-9Fe-.7Mo-3Ti
10,461	SPS TECHNOLOGIES	4.25:1	7052	1093	Co-27Ni-19Cr-1.4Al-9Fe-.7Mo-3Ti
10,462	GE/EVENDALE	9:1	7052	1316	A/o-Ti-52-Al-2Ta
10,463	GE/EVENDALE	9:1	7052	1316	A/o-Ti-52Al-2Ta-.2B
10,464	GE/EVENDALE	9:1	7052	1316	A/o-Ti-50Al-2Cr
10,465	MLLS	8.1	1066	1066	Ti-Al
10,466	GE/EVENDALE	9:1	7052	1316	A/o-Ti-48Al-2Cr
10,467	GE/EVENDALE	9:1	7052	1316	A/o-Ti-48Al-2Cr-2Si
10,468	P&W/FL	10:1	7052	1121	Ti-36.9Al-8.8Ta
10,469	P&W/FL	10:1	7052	1121	Ti-33.3Al-.95Ta
10,470	P&W/FL	10:1	7052	1121	Ti-36.9Al-8.8Ta
10,471	P&W/FL	10:1	7052	1149	Ti-33.3Al-5.6Al-.95Ta
10,472	P&W/FL	12:1	7052	1121	Ti-36.9Al-8.8Ta
10,473	P&W/FL	8:1	7052	1121	Ti-33.3Al-5.6Al-.95Ta
10,474	MARTIN-MARIETTA	13.5:1	7052	1050	Ti-45Al-30NbB_2
10,475	MARTIN-MARIETTA	13.5:1	7052	1050	Ti-48Al
10,476	MARTIN-MARIETTA	13.5:1	7052	1050	_-48Al
10,477	GE/EVENDALE	Blank	C300/Poly	1010	Ni-17Co-15Cr-2.5Al-4.7Ti-1.6Nb-.030B-.06C-.06Zr
10,478	GE/EVENDALE	Blank	C300/Poly	1010	Ni-18Co-16Cr-5Mo-3W-2.5Al-3Ti-3Nb-.030B-.05C-.05Zr
10,479	GE/EVENDALE	Blank	C300/Poly	1066	Ni-18Co-12Cr-4Mo-4Al-4Ti-2Nb-.030B-.03C-.03Zr

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,480	GE/EVENDALE	Blank	C300/Poly	1066	Secrecy Order
10,481	GE/EVENDALE	7.5:1	7052	1038	Ni-17Co-15Cr-5Mo-2.5Al-4.7Ti-1.6Nb-.030B-.06C-.06Zr
10,482	GE/EVENDALE	7.5:1	7052	1038	Ni-18Co-16Cr-5Mo-3W-2.5Al-3Ti-3Nb-.03B-.05C-.05Zr
10,483	GE/EVENDALE	7.5:1	7052	1082	Ni-18Co-12Cr-4Mo-4Al-4Ti-2Nb-.03B-.03C-.03Zr
10,484	GE/EVENDALE	7.5:1	7052	1082	Secrecy Order
10,485	GE/EVENDALE	Blank	C300/Poly	1010	Ni-13.0Co-16.0Cr-5.5Mo-2.1Al-3.7Ti-2.0Nb-.015B-.03C-.03Zr
10,486	GE/EVENDALE	Blank	C300/Poly	1010	Ni-13.0Co-16.0Cr-5.5Mo-2.1Al-3.7Ti-2.0Nb-.015B-.03C-.03Zr
10,487	GE/EVENDALE	Blank	C300/Poly	1010	Ni-18.0Co-16.0Cr-5.0Mo-3.0W-2.5Al-3.0Ti-3.0Nb-.030B-.05C-.05Zr
10,488	GE/EVENDALE	Blank	C300/Poly	1066	Ni-17.0Co-15.0Cr-5.0Mo-2.5Al-4.7Ti-1.6Nb-.030B-.06C-.06Zr
10,489	GE/EVENDALE	Blank	C300/Poly	1093	Ni-18.0Co-12.0Cr-4.0Mo-4.0Al-4.0Ti-2.0Nb-.030B-.03C-.03Zr
10 490	GE/EVENDALE	Blank	C300/Poly	1121	Secrecy Order
10,491	GE/EVENDALE	9:1	7052	1316	Ti-Al(Gamma) Proprietary
10,492	GE/EVENDALE	9:1	7052	1316	Ti-Al(Gamma) Proprietary
10,493	GE/EVENDALE	9:1	7052	1316	Ti-Al(Gamma) Proprietary

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,494	GE/EVENDALE	9:1	7052	1316	Ti-Al (Gamma) Proprietary
10,495	GE/EVENDALE	9:1	7052	1316	Ti-Al (Gamma) Proprietary
10,496	GE/EVENDALE	9:1	7052	1316	Ti-Al (Gamma) Proprietary
10,497	GE/EVENDALE	9:1	7052	1316	Ti-Al (Gamma) Proprietary
10,498	GE/EVENDALE	9:1	7052	1316	Ti-Al (Gamma) Proprietary
10,499	GE/EVENDALE	7.1:1	7052	1038	Ni-13Co-16Cr-5.5Mo-2.1Al-3.7Ti-2.0Nb-.015B-.03C-.03Zr
10,500	GE/EVENDALE	7.1:1	7052	1038	Ni-13.0Co-16Cr-5.5Mo-2.1Al-3.7Ti2.0Nb-.015B-.03C-.03Zr
10,501	GE/EVENDALE	7.1:1	7052	1038	Ni-18Co-16Cr-5Mo-3.0W-2.5Al-3.0Ti-3.0Nb-.030B-.05C-.05Zr
10,502	GE/EVENDALE	7.1:1	7052	1093	Ni-17Co-15Cr-5.0Mo-2.5Al-4.7Ti-1.6Nb-.030B-.06C-.06Zr
10,503	GE/EVENDALE	7.1:1	C300/Poly	1010	Ni-17.0Co-15.0Cr-5.0Mo-2.5Al-4.7Ti-1.6Nb-.030B-.06C-.06Zr
10,504	GE/EVENDALE	Blank	C300/Poly	1010	Ni-13.0Co-16.0Cr-5.0Mo-2.1Al-3.7Ti-2.0Nb-.015B-.03C-.03Zr
10,505	GE/EVENDALE	Blank	C300/Poly	1010	Ni-18.0Co-16.0Cr-5.0Mo-3.0W-2.5Al-3.0Ti-3.0Nb-.030B-.05C-.05Zr
10,506	GE/EVENDALE	Blank	C300/Poly	1010	Ni-17.0Co-15.0Cr-5.0Mo-2.5Al-4.7Ti-1.6Nb-.030B-.06C-.06Zr

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
10,507	GE/EVENDALE	Blank	C300/Poly	1010	Ni-13.0Co-16.0Cr-5.5Mo-2.1Al-3.7Ti-2.0Nb-.015B-.03C-.03Zr
10,508	GE/EVENDALE	Blank	C300/Poly	1010	Ni-18.0Co-16.0Cr-5.0Mo-3.0W-2.5Al-3.0Ti-3.0Nb-.030B-.05C-.05Zr
10,509	GE/EVENDALE	Blank	C300/Poly	1066	Ni-11.92Co-12.80Cr-5.06Mo-2.61Al-4.89Ti-1.63Nb-.2Hf-.015B-.03C-.03Zr
10,510	GE/EVENDALE	Blank	C300/Poly	1066	Ni-18.0Co-12.0Cr-4.0Mo-4.0Al-4.0Ti-2.0Nb-.030B-.03C-.03Zr
10,511	GE/EVENDALE	Blank	C300/Poly	1066	Secrecy
10,512	GE/EVENDALE	Blank	C300/Poly	1066	Ni-11.92Co-12.80Cr-5.06Mo-2.61Al-4.89Ti-1.63Nb-.2Hf-.015B-.03C-.03Zr
10,513	GE/EVENDALE	Blank	C300/Poly	1066	Ni-18.0Co-12.0Cr-4.0Mo-4.0Al-4.0Ti-2.0Nb-.030B-.03C-.03Zr
10,514	GE/EVENDALE	Blank	C300/Poly	1066	Secrecy
10,515	GE/EVENDALE	Blank	C300/Poly	1066	Ni-11.92Co-12.80Cr-5.06Mo-2.61Al-4.89Ti-1.63Nb-.2Hf-.015B-.03C-.03Zr
10,516	GE/EVENDALE	Blank	C300/Poly	1066	Ni-11.92Co-12.80Cr-5.06Mo-2.61Al-4.89Ti-1.63Nb-.2Hf-.015B-.03C-.03Zr
10,517	GE/EVENDALE	7.1:1	7052	1038	Ni-17.0Co-15.0Cr-5.0Mo-2.5Al-4.7Ti-1.6Nb-.03B-.06C-.06Zr
10,518	GE/EVENDALE	7.1:1	7052	11038	Ni-13.0Co-16.0Cr-5.5Mo-2.1Al-3.7Ti-2.0Nb-.015B-.03C-.03Zr
10,519	GE/EVENDALE	7.1:1	7052	1038	Ni-18.0Co-16.0Cr-5.0Mo-2.5Al-4.7Ti-.6Nb-.030B-.06C-.06Zr

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,520	GE/EVENDALE	7.1:1	7052	1038	Ni-17.0Co-15.0Cr-2.5Al-4.7Ti-1.6Nb-.030B-.06C-.06Zr
10,521	GE/EVENDALE	7.1:1	7052	1038	Ni-13.0Co-16.0Cr-5.5Mo-2.1Al-3.7Ti-2.0Nb-.015B-.03C-.03Zr
10,522	GE/EVENDALE	7.1:1	7052	1038	Ni-18.0Co-16.0Cr-5.0Mo-3.0W-2.5Al-3.0Ti-3.0Nb-.030B-.05C-.05Zr
10,523	GE/EVENDALE	7.1:1	7052	1066	Ni-11.92Co-12.80Cr-5.06Mo 2.61Al-4.89Ti-1.63Nb-.2Hf-.015B-.03C-.03Zr
10,524	GE/EVENDALE	7.1:1	7052	1066	Ni-18.0Co-12.0Cr-4.0Mo-4.0Al-4.0Ti-2.0Nb-.030B-.03C-.03Zr
10,525	GE/EVENDALE	7.1:1	7052	1066	Secrecy
10,526	GE/EVENDALE	7.1:1	7052	1066	Ni-11.92Co-12.80Cr-5.06Mo-2.61Al-4.89Ti-1.63Nb-.2Hf-.015B-.03C-.03Zr
10,527	GE/EVENDALE	7.1:1	7052	1066	Ni-18.0Co-12.0Cr-4.0Mo-4.0Al-4.0Ti-2.0Nb-.030B-.03C-.03Zr
10,528	GE/EVENDALE	7.1:1	7052	1066	Secrecy
10,529	GE/EVENDALE	7.1.1	7052	1066	Ni-11.92Co-12.80Cr-5.06Mo-2.61Al-4.89Ti-1.63Nb-.2Hf-.015B-.03C-.03Zr
10,530	WRDC/MLLS	8:1	7052	1093	Ti-34Al-5Nb-1Ta
10,531	WRDC/METCUT	Blank	C300/Poly	1038	Ti-34.1Al-4.6Nb-1Ta
10,532	WRDC/METCUT	8:1	7052	1038	Ti-34.1Al-4.6Nb-1Ta
10,533	MARTIN-MARIETTA	13.5:1	7052	1300	Ti-45Al-30V/oNbB_2
10,534	MARTIN-MARIETTA	13.5:1	7052	1300	Ti-45Al-30V/oTaB_2
10,535	P&W/FL	Blank	7052	1121	Ti-33.3Al-5.6Al-.95Ta

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
10,536	P&W/FL	Blank	7052	1121	Ti-36.9Al-8.8Ta
10,537	P&W/FL	Blank	7052	1149	Ti.33.3Al-5.6Al-.95Ta
10,538	P&W/FL	Blank	7052	1149	Ti-36.9Al-8.8Ta
10,539	GE/EVENDALE	13.5:1	7052	1316	Ti-Al (Secret)
10,540	GE/EVENDALE	6.5:1	7052	1316	Ti-Al (Secret)
10,541	GE/EVENDALE	6.5:1	7052	1316	Ti-Al (Secret)
10,542	GE/EVENDALE	6.5:1	7052	1316	Ti-Al (Secret)
10,543	GE/EVENDALE	6.5:1	7052	1316	Ti-Al (Secret)
10,544	P&W/FL	9:1	7052	1066	Ti-33.7Al-5.7Nb-1.4Ta-.04B
10,545	P&W/FL	9:1	7052	1066	Ti-33.7Al-5.7Nb-1.4Ta-.04B
10,546	P&W/FL	9:1	7052	1066	Ti-48Al-2.5Nb-.31A-.15B-20v/o-Ti-Nb
10,547	P&W/FL	9:1	7052	1066	Ti-48Al-2.5Nb-.31a-.15B-20v/o-Ti-Nb
10,548	P&W/FL	9:1	7052	1066	Ti-48Al-2.5Nb-.31a-.15-20v/o-Ti-Nb
10,549	P&W/FL	9:1	7052	1066	Ti-48Al-2.5Nb-.31a-.15B-20v/o-Ti-Nb
10,550	P&W/FL	9:1	7052	1066	Ti-51Al-2.5Nb-.3Ta-A/o
10,551	P&W/FL	9:1	7052	1066	Ti-51Al-2.5Nb-.3Ta-A/o
10,552	P&W/FL	9:1	7052	1066	Ti-51Al-2.5Nb-.3Ta-A/o
10,553	P&W/FL	9:1	7052	1066	Ti-32Al-6.9Nb-4.5Ta-.04B
10,554	P&W/FL	9:1	7052	1066	Ti-32Al-6.9Nb-4.5Ta-.04B
10,555	P&W/FL	9:1	7052	1343	Ti-51Al-2.5Nb-.3Ta-A/o
10,556	P&W/FL	9:1	7052	1343	Ti-51Al-2.5Nb-.3Ta-A/o

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,557	P&W/FL	9:1	7052	1343	Ti-51Al-2.5Nb-.3Ta-A/o
10,558	UES	Streamline "P"	C300/Poly	454	Al-Li
10,559	UES	14:1	C300/Poly	454	Al-Li
10,560	UES	14:1	C300/Poly	371	Al-Li
10,561	UES	14:1	C300/Poly	371	Al-Li
10,562	SPS	4.2:1	7052	1093	Co-27Ni-19Cr
10,563	SPS	4.2:1	7052	1093	Co-27Ni-19Cr
10,564	SPS	4.2:1	7052	1093	Co-27Ni-19Cr
10,565	SPS	4.2:1	7052	1093	Co-27Ni-19-Cr
10,566	SPS	4.2:1	7052	1093	Co-27Ni-19Cr
10,567	SPS	4.2:1	7052	1093	Co-27Ni-19Cr
10,568	SPS	4.2:1	7052	1093	Co-27-Ni-19Cr
10,569	SPS	4.2:1	7052	1093	Co-27-Ni-19Cr
10,570	SPS	4.2:1	7052	1093	Co-27-Ni-19Cr
10,571	P&W/FL	10.2:1	7052	1149	Ti-33.3Al.5.6Al-.95Ta
10,572	P&W/FL	10.2:1	7052	1149	Ti-36.9Al-8.8Ta
10,573	P&W/FL	10.2:1	7052	1121	Ti-33.3Al-5.6Al-.95Ta
10,574	P&W/FL	10.2:1	7052	1121	Ti-36.9Al-8.8Ta
10,575	P&W/FL	10.6:1	7052	1066	Ti-33.6Al-5.2Nb-.96Ta
10,576	P&W/FL	10.6:1	7052	1066	Ti-33.6Al-5.2Nb-.96Ta
10,577	P&W/FL	10.6:1	7052	1066	Ti-33.6Al-5.2Nb-.96Ta
10,578	P&W/FL	10.6:1	7052	1C66	Ti-33.6Al-5.3Nb-.96Ta
10,579	P&W/FL	10.6:1	7052	1066	Ti-33.6Al-5.2Nb-.96Ta
10,580	P&W/FL	10.6:1	7052	1066	Ti 33.6Al-5.2Nb-.96Ta

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
10,581	METCUT	Blank	C300/Poly	250	Mg
10,582	METCUT	Blank	C300/Poly	250	Mg
10,583	METCUT	Blank	C300/Poly	250	Mg
10,584	P&W/FL	10.5:1	7052	1066	Ti-35.2Al-8.9Ta
10,585	P&W/FL	10.5:1	7052	1066	Ti-35.2Al-8.9Ta
10,586	P&W/FL	10.5:1	7052	1066	Ti-35.2Al-8.9Ta
10,587	P&W/FL	10.5:1	7052	1066	Ti-35.2Al-8.9Ta
10,588	P&W/FL	10.5:1	7052	1066	Ti-35.2Al-8.9Ta
10,589	P&W/FL	10.5:1	7052	1066	Ti-35.2Al-8.9Ta
10,590	P&W/FL	10.5:1	7052	1010	Ti-33.6Al-5.2Nb-.96Ta
10,591	P&W/FL	10.5:1	7052	1066	Ti-33.0Al-5.3Nb-1.5V
10,592	P&W/FL	10.5:1	7052	1066	Ti-33.2Al-5.4Nb-2.9V
10,593	P&W/FL	8:1	7052	1066	Ti-33.6Al-5.2Nb-.96Ta
10,594	P&W/FL	15:1	7052	1066	Ti-33.6Al-5.2Nb-.96Ta
10,595	P&W/FL	20:1	7052	1066	Ti-33.6Al-5.2Nb-.96Ta
10,596	P&W/FL	10:1	7052	11066	Ti-33.0Al-5.3Nb-1.5V
10,597	P&W/FL	10:1	7052	1066	Ti-33.2Al-5.4Nb-2.9V
10,598	P&W/FL	10.5:1	7052	982	Ti-33.6Al-5.2Nb-.96Ta
10,599	GE/EVENDALE	13.5:1	7052	1371	Ti-48Al-1W-A/o
10,600	GE/EVENDALE	9.5:1	7052	1066	Ti-25Al-11Nb-3Mo-A/o
10,601	GE/EVENDALE	9.5:1	7052	1316	Ti-48Al-5Nb-2Ta-2V-A/o
10,602	GE/EVENDALE	9.5:1	7052	1316	Ti-48Al-5Nb-2Ta-A/o
10,603	GE/EVENDALE	9.5:1	7052	1316	Ti-48Al-5Ta-.2B-A/o
10,604	METCUT	Blank	C300/Poly	250	Mg
10,605	METCUT	Blank	C300/Poly	250	Mg

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
10,606	METCUT	Blank	C300/Poly	250	Mg
10,607	MARTIN-MARIETTA	14.5:1	7052	1050	Ti-48Al
10,608	MARTIN-MARIETTA	14.5:1	7052	1050	Ti-48Al
10,609	METCUT	12:1	C300/Poly	350	Mg
10,610	METCUT	12:1	C300/Poly	350	Mg
10,611	METCUT	6:1	C300/Poly	350	Mg
10,612	METCUT	20:1	C300/Poly	350	Mg
10,613	METCUT	30:1	C300/Poly	350	Mg
10,614	MARTIN-MARIETTA	14.5:1	7052	1250	Ti-48Al
10,615	GE/EVENDALE	Blank	C300/Poly	1010	Ni-13.0Co-16.0Cr-5.5Mo-2.1Al-3.7Ti-2.0Nb-.015B-.03C-.03Zr
10,616	GE/EVENDALE	Blank	C300/Poly	1066	Ni-11.92Co-12.8Cr-5.06Mo-2.61Al-4.89Ti-1.63Nb-.2Hf-.015B-.03C-.03Zr
10,617	GE/EVENDALE	Blank	C300/Poly	1066	Ni-11.92Co-12.8Cr-5.06Mo-2.61Al-4.89Ti-1.63Nb-.2Hf-.015B-.03C-.03Zr
10,618	GE/EVENDALE	Blank	C300/Poly	1093	Ni-18.0Co-12.0Cr-4.0Mo-4.0Al-.4Ti-2.0Nb-.030B-.03C-.03Zr
10,619	GE/EVENDALE	Blank	C300/Poly	1121	Ni
10,620	P&W/FL	10.2:1	7052	1066	Ti-50Al-5Nb-.3Ta
10,621	P&W/FL	10.2:1	7052	1066	Ti-50Al-5Nb-.3Ta
10,622	P&W/FL	10.3:1	7052	1066	Ti-50Al-5Nb-.3Ta
10,623	P&W/FL	10.2:1	7052	1066	Ti-50Al-5Nb-.3Ta
10,624	P&W/FL	10.2:1	7052	1066	Ti-50Al-5Nb-.3Ta
10,625	P&W/FL	10.2:1	7052	1066	Ti-50Al-5Nb-.3Ta
10,626	P&W/FL	10.2:1	7052	1066	Ti-50Al-.5Nb-.3Ta

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
10,627	GE/EVENDALE	7:1	7052	1038	Ni-13.0Co-16.0Cr-5.5Mo-2.1Al-3.7Ti-2Nb-.015B-.03Cr-.03Zr
10,628	GE/EVENDALE	7:1	7052	1093	Ni-11.92Co-12.8Cr-5.06Mo-2.6Al-4.89Ti-1.63Nb-.2Hf-.015B-.03C-.03Zr
10,629	GE/EVENDALE	7:1	7052	1093	Ni-11.92Co-12.80Cr-5.06Mo-2.61Al-4.89Ti-1.63Nb-.2Hf-.015B-.03C-.03Zr
10,630	GE/EVENDALE	7:1	7052	1121	Ni-18.0Co-12.0Cr-4.0Mo-4.0Al-4Ti-2.0Nb-.030B-.03C-.03Zr
10,631	GE/EVENDALE	7:1	7052	1149	Ni-Base (Secret)
10,632	P&W/FL	10:1	7052	1066	Ti-50Al-5Nb-.3Ta
10,633	P&W/FL	10:1	7052	1066	Ti-50Al-5Nb-.3Ta
10,634	P&W/FL	10:1	7052	1066	Ti-50Al-5Nb-.3Ta
10,635	P&W/FL	10:1	7052	1066	Ti-50Al-5Nb-.3Ta
10,636	P&W/FL	10:1	7052	1066	Ti-50Al-5Nb-.3Ta
10,637	P&W/FL	10:1	7052	1066	Ti-50Al-5Nb-.3Ta
10,638	P&W/FL	10:1	7052	1066	Ti-50Al-5Nb-.3Ta
10,639	P&W/FL	10:1	7052	1343	Ti-50Al.5Nb-.3Ta
10,640	P&W/FL	10:1	7052	1343	Ti-50Al.5Nb-.3Ta
10,641	P&W/FL	10.1	7052	1343	Ti-50Al-5Nb-.3Ta
10,642	P&W/FL	10:1	7052	1343	Ti-50Al-5Nb-.3Ta
10,643	P&W/FL	10:1	7052	1343	Ti-50Al-5Nb-.3Ta
10,644	P&W/FL	10:1	7052	1343	Ti-50Al-5Nb-.3Ta
10,645	P&W/FL	10:1	7052	1343	Ti-50Al-5Nb-.3Ta
10,646	P&W/FL	10:1	7052	1343	Ti-50Al-5Nb-.3Ta

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,647	P&W/FL	10:1	7052	1343	Ti-50Al-5Nb-.3Ta
10,648	P&W/FL	10:1	7052	1343	Ti-50Al-5Nb-.3Ta
10,649	P&W/FL	10:1	7052	1343	Ti-50Al-5Nb-.3Ta
10,650	P&W/FL	10:1	7052	1343	Ti-50Al-5Nb-.3Ta
10,651	P&W/FL	8:1	7052	1288	
10,652	P&W/FL	10:1	7052	1288	
10,653	P&W/FL	10:1	7052	1288	
10,654	P&W/FL	15:1	7052	1066	
10,655	P&W/FL	10:1	7052	1010	
10,656	GE/EVENDALE	Blank	C300/Poly	1066	Ni-Base (Secret)
10,657	GE/EVENDALE	Blank	C300/Poly	1066	Ni-Base (Secret)
10,658	GE/EVENDALE	Blank	C300/Poly	1066	Ni-Base (Secret)
10,659	GE/EVENDALE	Blank	C300/Poly	1066	Ni-Base (Secret)
10,660	P&W/HARTFORD	9:1	7052	999	Ni-Al
10,661	P&W/HARTFORD	9:1	7052	999	Ni-Al
10,662	McDONNELL DOUGLAS	16:1	7052	1288	Ti-34Al-1.5V
10,663	McDONNELL DOUGLAS	16:1	7052	1288	Ti-34Al-4.5V
10,664	McDONNELL DOUGLAS	16:1	7052	1288	Ti-34Al-8Ta
10,665	McDONNELL DOUGLAS	16:1	7052	1288	Ti-33Al-5Nb-1.4Ta
10,666	GE/EVENDALE	7:1	7052	1093	Ni-Base (Secret)
10,667	GE/EVENDALE	7:1	7052	1093	Ni-Base (Secret)
10,668	GE/EVENDALE	7:1	7052	1093	Ni-Base (Secret)

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,669	GE/EVENDALE	7:1	7052	1093	Ni-Base (Secret)
10,670	GE/EVENDALE	7:1	7052	1093	Ni-Base (Secret)
10,671	GE/EVENDALE	7:1	7052	1093	Ni-Base (Secret)
10,672	GE/EVENDALE	7:1	7052	1121	Ni-Base (Secret)
10,673	McDONNELL-DOUGLAS	16:1	7052	1204	Ti-14Al-20Nb-3.2V-3Mo
10,674	McDONNELL-DOUGLAS	16:1	7052	1260	Ti-14Al-20Nb-1B-1Si
10,675	McDONNELL-DOUGLAS	15:1	7052	1260	Ti-34Al-1.5V-20Vol.%-TiNb
10,676	METCUT	8.5:1	7052	1149	Ti-31.8Al-11.1Nb-.8Ta-1B
10,677	METCUT	14.5:1	7052	1149	Ti-34.1Al-4.6Nb-1Ta-.18C-.130
10,678	METCUT	8.5:1	7052	1149	Ti-50Al
10,679	METCUT	6:1	7052	1054	Ti-25Al-10Nb
10,680	METCUT	6:1	7052	1010	Ti-25Al-25Nb
10,681	METCUT	6:1	7052	1149	Ti-50Al
10,682	GE/EVENDALE	6.5:1	7052	1316	IR&D-Ti-Al (Secret)
10,683	GE/EVENDALE	20:1	7052	1316	IR&D-Ti-Al (Secret)
10,684	GE/EVENDALE	20:1	7052	1316	IR&D-Ti-Al (Secret)
10,685	GE/EVENDALE	12:1	7052	1038	IR&D-Ti-Al (Secret)
10,686	GE/EVENDALE	23:1	7052	1038	IR&D-Ti-Al (Secret)
10,687	GE/EVENDALE	23:1	7052	1038	IR&D-Ti-Al (Secret)
10,688	GE/EVENDALE	8.1:1	7052	1371	IR&D-Ti-Al (Secret)
10,689	GE/EVENDALE	8.1:1	7052	1371	IR&D-Ti-Al (Secret)
10,690	UES	4.4:1	7052	1500	Nb-5w/o-Si
10,691	UES	4.4:1	Bare	1649	Nb-3.25w/o-Si

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,692	P&W/FL	10:1	7052	1260	Ti-34.1Al-8.86Ta
10,693	P&W/FL	15:1	7052	1260	Ti-34.1Al-8.6Ta
10,694	P&W/FL	10:1	7052	1316	Ti-34.1Al-8.86Ta
10,695	GE/EVENDALE	8:1	Bare	1316	IR&D-Ti-Al (Secret)
10,696	GE/EVENDALE	8:1	7052	1371	IR&D-Ti-Al (Secret)
10,697	GE/EVENDALE	8:1	7052	1371	IR&D-Ti-Al (Secret)
10,698	GE/EVENDALE	20:1	7052	1371	IR&D/Ti-Al (Secret)
10,699	GE/EVENDALE	8:1	7052	1316	IR&D-Ti-Al (Secret)
10,700	GE/EVENDALE	Blank	C300/Poly	1010	IR&D-Ni-Alloy) (S)
10,701	GE/EVENDALE	Blank	C300/Poly	1066	IR&D-Ni Alloy (S)
10,702	GE/EVENDALE	Blank	C300/Poly	1066	Ni-Alloy (S)
10,703	GE/EVENDALE	Blank	C300/Poly	1121	Ni-Alloy (S)
10,704	McDONNELL DOUGLAS	15:1	7052	999	Ti-1B
10,705	McDONNELL DOUGLAS	15:1	7052	999	Ti-2Er
10,706	GE/EVENDALE	7:1	7052	1025 Furnace Cut-Off	Ni-Alloy (S)
10,707	GE/EVENDALE	7:1	7052	1093	Ni-Alloy (S)
10,708	GE/EVENDALE	7:1	7052	1093	Ni-Alloy (S)
10,709	GE/EVENDALE	7:1	7052	1149	Ni-Alloy (S)
10,710	GE/EVENDALE	Blank	C300/Poly	1010	Ni-Alloy (S)
10,711	GE/EVENDALE	Blank	C300/Poly	1010	Ni-Alloy (S)
10,712	GE/EVENDALE	Blank	C300/Poly	1010	Ni-Alloy (S)
10,713	GE/EVENDALE	Blank	C300/Poly	1010	Ni-Alloy (S)
10,714	McDONNELL DOUGLAS	15:1	7052	1260	Ti-16Al-1B

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (°C)	Composition
10,715	McDONNELL DOUGLAS	15:1	7052	1260	Ti-16Al-2Er
10,716	MARTIN-MARIETTA	8.5:1	7052	849	XD (Tm Cu)
10,717	MARTIN-MARIETTA	Blank	C300/Poly	849	XD (Tm Cu)
10,718	MARTIN-MARIETTA	8.5:1	7052	849	XD (Tm Cu)
10,719	MARTIN-MARIETTA	8.5:1	7052	849	XD (Tm Cu)
10,720	McDONNELL DOUGLAS	15:1	7052	1343	Ti-34Al-1B
10,721	McDONNELL DOUGLAS	15:1	7052	1343	Ti-34Al-2Er
10,722	GE/EVENDALE	Blank	C300/Poly	1066	Ni-Alloy (Secret)
10,723	GE/EVENDALE	Blank	C300/Poly	1066	Ni.Alloy (Secret)
10,724	GE/EVENDALE	Blank	C300/Poly	1066	Ni-Alloy [Secret)
10,725	GE/EVENDALE	Blank	C300/Poly	1066	Ni Alloy (Secret)
10,726	GE/EVENDALE	Blank	C300/Poly	1066	Ni Alloy (Secret)
10,727	GE/EVENDALE	7:1	7052	1038	Ni-Alloy (Secret)
10,728	GE/EVENDALE	7:1	7052	1038	Ni-Alloy (Secret
10,729	GE/EVENDALE	7:1	7052	1038	Ni-Alloy (Secret)
10,730	GE/EVENDALE	7:1	7052	1038	Ni-Alloy (Secret)
10,731	GE/EVENDALE	7:1	7052	1066	Ni-Alloy (Secret)
10,732	GE/EVENDALE	7:1	7052	1066	Ni-Alloy (Secret)
10,733	GE/EVENDALE	7:1	7052	1066	Ni-Alloy (Secret)
10,734	GE/EVENDALE	7:1	7052	1066	Ni-Alloy (Secret)
10,735	GE/EVENDALE	7:1	7052	1066	Ni-Alloy (Secret)
10,736	GE/EVENDALE	7:1	7052	1066	Ni-Alloy (Secret)
10,737	WRDC/MLLM	4.4:1	C300/Poly	900	Mg
10,738	WRDC/MLLM	4.4:1	C300/Poly	900	Mg
10,739	WRDC/MLLM	4.4:1	C300/Poly	950	Mg

TABLE III-1: Billets Processed by Extrusion--Continued

Extrusion No.	Source	Reduction Ratio	Billet Lubricant	Temp. (^{o}C)	Composition
10,740	WRDC/MLLM	4.5:1	C300/Poly	900	Mg
10,741	WRDC/MLLM	4.4:1	C300/Poly	800	Mg
10,742	WESTINGHOUSE	13:1	7052	1900	Ti-6Al-2Sn-4Zr-2Mg
10,743	WESTINGHOUSE	17:1	7052	1900	Ti-6Al-2Sn-4Zr-2Mg

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